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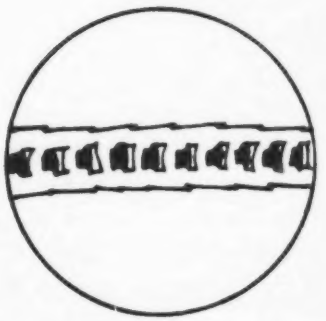
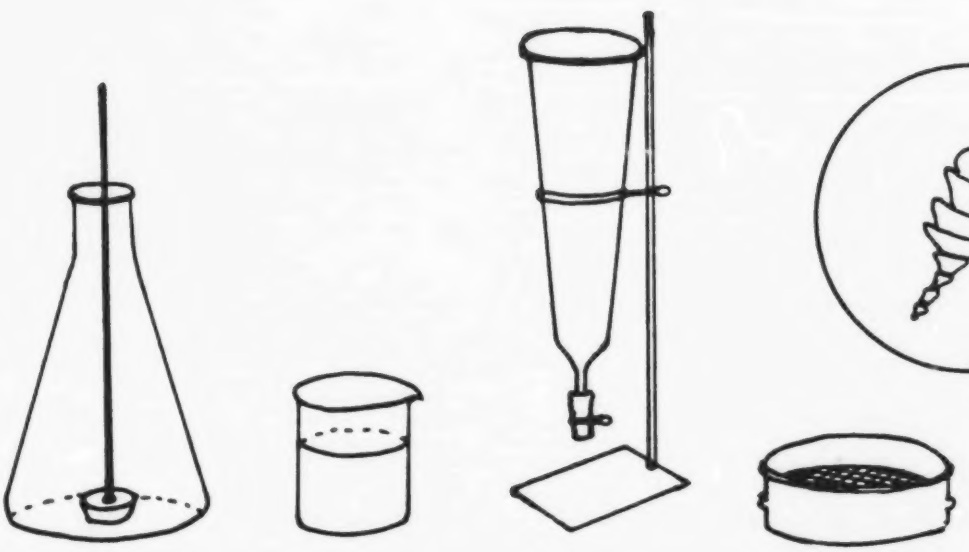
EXTRANEOUS MATTER IN FOODS

DETECTION, IDENTIFICATION AND EVALUATION

Diane McClymont Peace and Mary-Ann Gardiner





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c Minister of Supply and Services Canada - 1990

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1. INTRODUCTION

Extraneous material has contaminated food for thousands of years. For example, stored food insects have been found in ancient Egyptian tombs. Even with today's modern technology, it is impossible to grow, harvest or process food without contamination from many sources. Although good sanitation practices can greatly reduce the amount of contamination, extraneous matter cannot be completely eliminated. Methods for detection and identification of extraneous material are designed to differentiate what is an acceptable level of contamination from what is excessive and from what reflects poor manufacturing practices or gross insanitation.

The purpose of this manual is to provide basic information on extraneous material in foods, its isolation, identification and evaluation. This information is useful for quality control personnel, inspectors and analysts in the food industry, in government and in universities who aim to achieve a high standard of safety and cleanliness in the Canadian food supply.

2. TYPES OF EXTRANEOUS MATERIAL

Extraneous Material or Extraneous Matter, the terms are used interchangeably, is defined by the American Association of Official Analytical Chemists (Horwitz, 1984) as any foreign matter in a product associated with objectionable conditions or practices in production, storage, or distribution. Included are filth, decomposed material (decayed tissues due to parasitic or nonparasitic causes), and miscellaneous matter such as sand and soil, glass, rust, or other foreign substances. Excluded are bacterial counts.

Filth is defined as any objectionable matter contributed by animal contamination of a product such as rodent, insect, or bird matter; or any other objectionable matter contributed by insanitary conditions.

Heavy Filth is material separated from a product by sedimentation based on different densities of filth, food particles, and immersion liquids such as chloroform and carbon tetrachloride. Examples of such filth are insect and rodent excreta pellets and pellet fragments, sand, and soil.

Light Filth is defined as particles that are oleophilic and are separated from a product by floating them in an oil-aqueous mixture. Examples are insect fragments, rodent hairs, and feather barbules.

Sieved Filth is defined as filth particles of specific size ranges separated quantitatively from a product by use of selected sieve mesh sizes.

Examples of different types of extraneous material are listed in Table 1. This list does not include all types of extraneous material, only the ones most frequently encountered. When reporting extraneous material, it is important to identify the particles in as much detail as possible. In the case of insects or insect fragments, for example, it is important to know the species or group to which they belong.

As can be seen from the list in Table 1, extraneous material does not include chemical contaminants or particles that are too small to be detected with a light microscope. Also excluded are any quality factors related to the variety, grade or ripeness of a food.

Examples of extraneous material found in six types of food that have been analyzed by the Health Protection Branch during the period of 1983-1988 are presented in Tables 2-7. The frequency of each kind of extraneous material in the six types of food is vastly different.

There are a large number of metal particles in grated cheese (Table 2) many of which come from the grating operation. Hairs of various types may enter the cheese during processing and grating operations. Wood fragments may originate from the pressing boxes. Insects and mites may enter the product in large numbers during storage. In jams and jellies (Table 3), the most frequent type of extraneous material is glass particles that enter during the filling process usually because of breakage of glass jars used to hold the product. In rice flour (Table 4) and pasta (Table 5), the most frequent types of extraneous material are insect fragments, hairs and feather barbules that enter in the field while these products are growing or while they are in storage. Metal particles can enter during grinding of the grains into flour. Black pepper (Table 6) is often contaminated with insect fragments, mites, hairs and feather barbules that can enter from the field or from storage. Sand and grit originate from dirty peppercorns that were not cleaned thoroughly during processing. Raisins (Table 7) are frequently contaminated with insects and insect fragments and to a lesser extent by hairs, feather barbules and mites. These can enter either in the field or during storage.

TABLE 1

TYPES OF EXTRANEOUS MATERIAL

bone fragments
carbon particles
cardboard
chewing gum
cigarettes or parts
cocoons
crystals
eggs, infestation type
excrement
feather barbules
fibres, textile
fibres, vegetable
food, overprocessed
food, underprocessed
glass particles
grease, oil
grit, sand, earth
hair
hide
insect excreta
insect fragments
insects
metal particles
mites
mould
nematodes
packaging material
paint
paper
pits, fruit
plastic pieces
rodent parts
rubber particles
shell
stems
struvite
trailings (extraneous food particles from equipment)
urine
wax particles
webbing
wood fragments
yeast

TABLE 2

EXTRANEOUS MATERIAL IN GRATED CHEESE
(306 subsamples analyzed, 1983-1988)

TYPE OF FILTH	FREQUENCY (%) ENCOUNTERED
metal particles	50
mammalian hairs other than rat or mouse	55
mites	29
insect fragments	28
wood fragments	24

TABLE 3

EXTRANEOUS MATERIAL IN JAMS AND JELLIES
(2520 subsamples analyzed, 1986-1988)

TYPE OF FILTH	FREQUENCY (%) ENCOUNTERED
glass particles	7
metal particles	3
plastic	0.5
pits (from fruits)	0.5

TABLE 4

EXTRANEOUS MATERIAL IN RICE FLOUR
(210 subsamples analyzed, 1983-1988)

TYPE OF FILTH	FREQUENCY (%) ENCOUNTERED
insect fragments	84
rat and mouse hairs	72
other mammalian hairs	62
feather barbules	30
mites	15
plastic or rubber pieces	13
metal particles	10

TABLE 5

EXTRANEOUS MATERIAL IN PASTA
(672 subsamples analyzed, 1983-1988)

TYPE OF FILTH	FREQUENCY (%) ENCOUNTERED
insect fragments	90
mammalian hairs other than rat or mouse	35
rat or mouse hairs	16
metal particles	9
feather barbules	4
plastic or rubber pieces	4
mites	3

TABLE 6

EXTRANEOUS MATERIAL IN GROUND BLACK PEPPER
(93 subsamples analyzed, 1983-1988)

TYPE OF FILTH	FREQUENCY (%) ENCOUNTERED
insect fragments	100
sand, grit	92
mites	72
rat or mouse hairs	63
feather barbules	60
other mammalian hairs	58

TABLE 7

EXTRANEOUS MATERIAL IN RAISINS
(288 subsamples analyzed, 1983-1988)

TYPE OF FILTH	FREQUENCY (%) ENCOUNTERED
insects and insect fragments	97
mammalian hairs other than rat or mouse	44
feather barbules	33
rat or mouse hairs	28
mites	21

3. SOURCES OF CONTAMINATION

Foods can be contaminated by extraneous material during any one of the following stages:

1. growth or production of the raw material before delivery to a factory
2. transport to or storage in a factory prior to processing
3. processing in the factory
4. storage in a factory or warehouse
5. handling at the wholesale or retail level
6. handling or storage by the consumer.

Field Contamination during Growth or Production

While a food is growing in the field, it is subject to contamination by a wide variety of sources such as field insects or mites that attack the foods; birds or rodents that leave feathers, hairs, excreta or excrement; mould or parasites that damage the foods and sand or grit that can become entrapped in the food. Some of this contamination is unavoidable because it is impossible to grow or harvest a food, even using the best and most up-to-date methods, without the presence of some foreign material.

Flies or wasps that are pollinating a flower may become entrapped in the fruit while it is being harvested. Members of the fig wasp, Blastophaga sp. are regularly seen in figs or fig paste because the females, which are necessary for pollination, get caught inside the female fruit. This wasp species completes its life cycle inside the male fig but often enters the female fig, perhaps by mistake. Scale insects of the superfamily Coccoidea, are small specialized insects that feed on many types of plants. Older nymphs and males are legless and wingless and usually attach themselves permanently to a plant by secreting a cover of wax over their body. As a result, they are difficult if not impossible to remove during processing or cleaning of a food. Because, in low numbers, they are unavoidable, we would expect to find some in most foods grown in the field. In high numbers, they reflect poor agricultural practices and in this case are avoidable.

Birds, during flight, may drop feathers or excrement onto a food that is growing in a field. Many of the feather barbules can be removed during cleaning. Bird excrement in food is not only revolting but may contain parasites such as the sporozoan, Toxoplasma gondii, which if kept moist can continue to be viable in the food (Gorham, 1975, 1985).

Many different fungi invade foods in the field. Fungal growth may manifest itself as rot spots of various sizes and colours, as scabs, slime, white cottony mycelia or as highly coloured mould. The fungus, Claviceps purpurea, attacks cereals such as rye. Some of the cereal grains are totally replaced by fungal tissues (ergot) which become hard and dark. If the ergot tissue is harvested and processed along with the normal grain, the resulting flour or bread contains toxic alkaloids which if ingested can cause ergotism, characterized by constricted blood vessels which may result in gangrene or spontaneous abortion or even death. Modern day cleaning and grading methods can remove most of the fungal material.

Sand, grit or soil can be splashed onto fruits or vegetables during heavy rainstorms, or enter the food by wind, cultivation or picking. A small amount of dirt is unavoidable but large amounts reflect poor agricultural practices and become objectionable because of the gritty texture they impart to the food. Chips of stone can also become an injury hazard if chewed by an unsuspecting consumer.

Contamination During Transport or Storage

During transport or storage, foods can become contaminated by stored product insects, mites, moulds and rats or mice which were harvested with the food or which were already present in the transport vehicles or warehouses. In Canada, stored product insects and mites cannot survive out-of-doors through the winter. They are, however, able to continue to reproduce when they are indoors in a warehouse where the temperature is above freezing. One of the most common stored product insects in Canada is the merchant grain beetle (Oryzaephilus mercator) which infests grains, nuts, dried fruits, yeast, sugar, candy, tobacco and dried meats. Females lay 50-300 eggs and produce 4-6 generations per year when they have abundant food and temperatures above freezing. They do not need a high relative humidity to survive. If left unchecked, this species can increase to tremendous numbers and cause serious damage to the food being stored.

Stored product mites (Plates 1 and 2) are very small (100-400 μm in length) and just visible to the naked eye. One female can produce 100-400 eggs which develop to adults in 1-4 months. Low numbers of stored product mites can be found on a wide variety of foods but the mites can increase to large numbers only where there is abundant food and where the relative humidity is fairly high (75-85%) such as on cheeses (Plate 3 (M)), hams and moist grains that are stored for long periods of time. Infestations are characterized by a layer of fine light brown dust that, when mounded into a small hill, will flatten in several minutes of its own accord because it is made up of moving mites as well as eggs, excreta, cast skins and bits of food (Plate 4). As well as eating food and decreasing its quality, stored product mites often cause allergies. Many people, especially those who clean or work with contaminated foods, become itchy, break out in a rash where exposed to the mites or develop asthma. Further information on the health hazards of mites is given in TerBush (1972).

The fungus Aspergillus flavus infects many foods in storage such as grains and peanuts. It produces aflatoxins which, if ingested, can damage the liver and other organs and may be carcinogenic.

During long term storage of grain, hot spots may develop where there are areas of high moisture such as leaks in a roof. Hot spots are characterized by cones of mouldy infested grain. Often the grain has sprouted on the top and formed a hard crust on the sides. Moulds such as Penicillium, Aspergillus, and Absidia spp.are favoured and multiply as well as insects (e.g. Cryptolestes ferrugineus, and Ahasverus advena) and mites (e.g. Glycyphagus destructor)(Sinha, 1961). As the organisms multiply, the grain temperature increases even more until charring occurs. The grain also becomes seriously contaminated with the infesting organisms and their excreta.

Contamination During Processing

In the factory, foods can be contaminated with any of the materials used in processing. For example, when cocoa beans are ground to make chocolate, fragments of metal break off the grinders during impact with the hard cocoa beans. Although some of the metal particles can be removed with magnets, large numbers of these particles may remain in the chocolate. Low numbers of metal particles are unavoidable but high numbers can be reduced by repairing or replacing the grinders or magnets. During the manufacture of skimmed milk powder, some of the milk particles become charred during spray drying. Low numbers are unavoidable but high numbers are avoidable and indicate that adjustment of equipment is necessary.

When bones are mechanically removed from meat to make meat products, bone chips and knife

fragments may enter the food. Both are injury hazards if an unsuspecting person chews or swallows the contaminant. Pit and pit fragments in pitted fruits such as dates and cherries cause the same type of injury hazard. Any product that is packaged in glass has the potential to be contaminated with glass fragments from breakage. Ingestion of glass fragments is a serious injury hazard. Contamination should be reduced as much as possible by reducing breakage or containing and cleaning up glass when breakage occurs.

Often a thick slimy growth composed of mould (mostly Geotrichum candidum), yeasts, bacteria and plant debris form on machinery that is used to process foods with a high moisture content. This slime grows quickly and contaminates the food. It is, however, easily removed with adequate cleaning procedures and killed by heating and disinfecting the equipment with chorine.

Although human hairs and textile fibres are not considered an injury hazard, they can find their way into the finished product in large numbers. Hairs and fibres are difficult to remove but the use of non-shedding and protective clothing can greatly reduce their incidence in food.

Contamination During Storage After Processing

After processing, foods are subject to the same type of contamination as before processing, mainly by insects, mites, moulds, rats, mice, birds etc., and packaging material.

Rats, namely the brown or Norway rat (Rattus norvegicus) and the black or roof rat (R. rattus), and the house mouse (Mus musculus) have been associated with man for over thousands of years. Wherever unprotected foods are stored, these rodents congregate. They chew food and foul it by urinating, defaecating and shedding hairs. Their habits of indiscriminately visiting drains, sewers, faeces, garbage, food and food handling surfaces make them a constant menace as carriers of diseases such as salmonellosis (Salmonella), one of the causal agents of food poisoning, moniliformis (Moniliformes moniliformes, an acanthocephala parasite) and leptospirosis (Spirochaeta sp.). The presence of rats or mice in a warehouse is indicated by faecal droppings (black or brown rod-shaped pellets, 8-20 mm x 4-8 mm for rat and 1-4 mm long for mouse), runways along floors, walls and ceilings that are dirty, footprints, holes, gnaw and tear marks on packaging, and piles of chewed food or packaging from nests. When bags are gnawed, the edges of the holes have a shredded, frayed or ragged appearance caused by the teeth of the rodent tearing and pulling at the threads. On whole grains, rodents often remove the germs with no apparent damage to the rest of the grain except for two scratches or punctures left by the teeth on the opposite side of the grain. On ears of corn, the tops of the kernels may be eaten and the lower white endosperm exposed. Tooth marks are usually evident. Rodents can gnaw their way into buildings through wooden doors or windows, or squeeze through channels for pipes or wires. The edges of holes are often stained with oil from their fur and feet. Rats and mice are usually nocturnal and not often seen during daytime inspections. Their damage is, however, evident to the trained eye. The publication by Brown (1968) describes the habits and detection of rodents. Positive identification of rodent damage can be confirmed in the laboratory by microscopic analysis of the structure of their hairs and microscopical and chemical analysis of their faeces.

Bats may also infest storage areas but usually only when sanitation measures are very lax. Their rodent-like pellets accumulate, often in piles, under the spot where they roost. Their pellets can be positively identified in the laboratory by the presence of bat hairs and, in the case of most infesting bats in Canada, by the presence of large numbers of insect fragments. Bats transmit many diseases to humans, the most important of which in Canada are histoplasmosis from inhalation of faeces dust, dermatomycosis from fungi they carry, and rabies from bites (Scott, 1966).

During storage, some products form crystals that are natural constituents of food but look like glass and are the cause of many consumer complaints. Examples are struvite (magnesium ammonium phosphate) in canned fish, calcium carbonate crystals in crab paste, calcium phosphate crystals in cheese and naringin ($C_{27}H_{30}O_{14}$) in underripe grapefruit pulp (Smith, 1983).

Contamination at the Wholesale or Retail Level

During handling at the wholesale or retail level, foods are subject to further contamination by insects, mites, rats, mice, moulds and packaging materials etc. Good storage practices should eliminate most of this contamination.

If a food that is infested with live organisms such as stored product mites enters an establishment where other foods are stored, it is easy for that contamination to spread. Because mites are very small, they are unsuspectedly carried from one place to another by air currents and by people passing by. Even though mites need a high relative humidity in order to survive, they can multiply quite readily on such foods as cheese, ham, dried apricots and dried mushrooms.

Cockroaches (Orthoptera) are often a problem in storage areas. They consume any human or animal food as well as fabric, paper, fur, leather etc. They feed on both decayed and sound food and often transmit diseases on their tarsi (feet) or other parts of their body. They are commonly implicated in the transmission of salmonellosis (food poisoning) and in toxoplasmosis caused by the protozoan parasite, Toxoplasma. Cockroaches, like rats and mice, are usually nocturnal but their presence can be suspected by collections of blunt excreta pellets (approximately 1 x 2 mm) in and around food.

Contamination by the Consumer

Extraneous material may enter a food by a consumer or by other agents in his household. Common contaminants are mould from other infected products, hairs from pets or humans, metal fragments from the process of opening cans, wood fragments from cutting boards, textile fibres from cloths, towels or clothing, paint chips from painted surfaces and insects from accidental entry.

Sabotage, or the deliberate contamination of a product, can occur at any stage during handling of a food. Suspected cases should be investigated to eliminate further occurence.

4. CONTROL

Good manufacturing practices (GMPs) are the standards used in the manufacture, processing, packaging and storage of foods to ensure a sanitary product. Good manufacturing practices involve:

1. hygiene in the production and harvesting areas
2. good design and hygiene of the establishment
3. hygienic and health requirements for personnel
4. hygiene for processing and storage.

General principles for hygiene in each of these areas are described for a wide variety of food handling establishments in the "Code of Practice: General Principles of Food Hygiene for Use by the Food Industry" (Health Protection Branch, 1983). More specific guidelines for good manufacturing practices are available from various industries, food associations and levels of governments. Some of the more important good manufacturing practices that apply to extraneous matter are summarized as follows.

Production and Harvesting Areas

Food should be grown under sound agricultural practices. Outbreaks of insects should be controlled. Rodents and other animals should be discouraged as much as possible from nesting in the production area. Harvesting, sorting and washing should be done in such a way as to minimize contamination. Produce should not be allowed to become dirty or contaminated with other infected food. Products to be dried outside should be done so with protection from rodents, birds, insects and unnecessary human handling.

Establishment

The exterior of the premises should be tidy with no piles of debris or vegetation near the buildings to harbour rats and mice. Garbage should be kept in animal-proof containers large enough to accommodate all garbage until collection or removal. The exterior of the buildings should be well sealed and doors, windows and vents screened to discourage entrance of animals. The interior of the premises should be well lit and uncluttered. Equipment should be in good working order and there should be adequate and separate storage for tools, sampling equipment and cleaning apparatus.

The floors should be swept daily and any spills cleaned immediately. Areas that could become contaminated should be disinfected. Effective insect and rodent control programs should be in operation as well as a sanitation program for the equipment.

Personnel

Personnel should be well trained in their job. They should wear protective clothing to prevent hairs and fibres from entering the food. They should not wear jewellery or carry unnecessary items in pockets. They should wash their hands whenever the risk of contamination may occur and they should not be suffering from any communicable disease which may contaminate the food.

Processing and Storage

Raw materials should be inspected immediately upon arrival, especially for live infestation of insects, mites or rodents. If live infestation is found, the product should be treated before the infestation has a chance to spread. Fumigation or other control treatments do not make a food acceptable. They only prevent infestation from spreading. The product has to be cleaned or sorted etc. to remove the contamination.

Processing equipment should be enclosed as much as possible to reduce the risk of entrance of extraneous materials. For example, where food is bottled in glass, safety features must be present to reduce or eliminate the entrance of glass particles, should breakage occur.

Stock should be stored at least 40 cm from walls to promote cleaning and to avoid formation of nooks and corners that afford protection for rats, mice and cockroaches etc.

Producing clean food does not necessarily require elaborate and expensive equipment. Basic good housekeeping works effectively to eliminate dirt, insects and rodents. When raw materials are carefully selected and processed according to good manufacturing practices with frequent inspections to see that these practices are actually followed, there is much less need for extensive follow-up of the finished product.

When good manufacturing practices are not followed and a product is contaminated, clean-up procedures are costly and time-consuming. For example, when a product such as fruit yogurt is contaminated with field insects that are visible to the consumer, complaints can result in a recall and in destruction of the entire product. Once such a product is manufactured it is impossible to remove this type of filth. Cereal that is contaminated with excessive or large metal particles, may result in many time-consuming inspections to find the source of contamination especially if many ingredients such as chopped fruits or nuts were added and these were not adequately checked for contamination before being incorporated in the finished product. Glass particles in bottled drinks are a serious injury hazard. If the contaminated product is not discovered until it reaches the consumer, it has to be recalled, often with considerable and undesirable publicity and expense. If a food is contaminated with live stored product insects or mites that have gone undetected until the product is distributed, not only does that product have to be recalled but every place where the product was handled or stored has to be cleaned and, in many cases, fumigated. If the infestation has spread to other products, they have to be recalled and treated as well, usually at the expense of the owner of the originally contaminated product. Determination of the owner at fault may require many legal investigations.

5. LAWS, REGULATIONS AND GUIDELINES

Almost every level of government has laws or regulations that deal with food sanitation. This legislation is based on the principles of good manufacturing practices. Although these practices vary from industry to industry, from year to year and in the state of art for that particular industry, commercial operations that follow these practices require little if any regulatory action.

International Regulations

The Codex Alimentarius Commission, which was formed in 1963 though the action of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), sets international standards for various foods that are traded on the international market such as coffee beans, dates and other dried fruits. In the case of dates, the standard covers requirements for the variety and size, the moisture content, pits in pitted dates, mineral impurities (heavy filth) and defects such as blemishes, damaged, unripe, unpollinated, dirty, insect and mite damaged and contaminated, soured, mouldy and decayed fruit.

U.S.A. Legislation

The Food, Drug and Cosmetic Act provides rules of conduct for manufacturers of foods, drugs and cosmetics. The Food and Drug Administration (FDA), Department of Health, Education and Welfare is the regulatory agency for this Act. This agency takes action when a food is manufactured, sold or stored under unsanitary conditions. A food, however, is not necessarily condemned because it contains foreign material especially in amounts below what can be removed or kept out of a product by good manufacturing practices. The FDA has designed a number of Defect Action Levels (DALs) that should not be exceeded if the food has been properly handled. For example, for wheat flour the DAL states that the food is unacceptable if it has insect filth with an average of 50 insect fragments or more per 50 g and/or rodent filth with an average of 1 rodent hair or more per 50 g of food.

Canadian Federal Government Laws

The two principal Canadian government agencies responsible for food safety are Health and Welfare Canada which administers the Food and Drugs Act and Agriculture Canada which handles the Meat Inspection Act. Two sections of the Food and Drugs Act that pertain to extraneous matter are:

Section 4. No person shall sell an article of food that

(a) has in or upon it any poisonous or harmful substance;
(b) is unfit for human consumption;
(c) consists in whole or in part of any filthy,putrid, disgusting, rotten decomposed or diseased animal or vegetable substance;
(d) is adulterated; or
(e) was manufactured, prepared, preserved, packaged or stored under unsanitary conditions.

Section 7. No person shall manufacture, prepare, preserve,package or store for sale any food under unsanitary conditions.

The federal government agencies handle inspection of all plants that ship food interprovincially or internationally. Agriculture Canada handles meat and most fresh fruits and vegetables and Health and Welfare Canada, for the most part, handles the rest. At times there is some overlap, but the agencies decide to allocate responsibility to one or the other to avoid duplication.

The Health Protection Branch of Health and Welfare Canada has designed various regulations and guidelines that pertain to specific foods and contaminants. Some of these are discussed in the Section "Three Class Acceptance Sampling Plan".

Provincial Government Regulations

The provincial governments inspect food processing operations that distribute only within their province such as beverage operations. Again there is some overlap with federal agencies and each attempts to avoid duplication.

Municipal Government Regulations

The municipal units inspect food establishments at the local retail level such as restaurants, fast food establishments and street vendors.

Canadian Grain Commission

This is the sole agency responsible for the grading and quality of domestic and imported grain.

Three Class Acceptance Sampling Plan

The Health Protection Branch has designed various guidelines to judge the levels of extraneous material that may be found in foods because it is impossible to produce foods that are totally free of extraneous material under good manufacturing practices.

The three class acceptance sampling plan is used to evaluate a lot to determine if different types of filth make the lot acceptable, marginally acceptable or unacceptable. According to the International Commission on Microbiological Specifications for Foods (ICMSF, 1986), four criteria are considered:

n =the number of analytical units that must be examined from a lot to satisfy the requirements of this acceptance plan.

m =a criterion which separates good quality from marginally acceptable quality. In general m represents an acceptable level and values above m but below or equal to M are marginally acceptable.

c =the maximum allowable number of marginally acceptable analytical units in an individual sample.

M = a criterion which separates marginally acceptable quality from defective quality. Values above M are unacceptable.

Each unit in the sample is analyzed and classified as either acceptable, marginally acceptable or defective using the class boundaries "m" and "M". If no defective units are found, or if the number of marginal units is equal to or less than "c", the lot is accepted. Otherwise the lot is rejected. That is the lot is rejected if:

(1) a single defect in one of the analytical units exceeds the permitted value of "M".
(2) the sample contains too many marginally acceptable analytical units. That is, the value for "c" has been exceeded.

In many cases, more than one type of filth is found in the same product. Each sample will yield a set of scores for each type of filth. Experience and judgement are used to consider the cumulative effect of having several types of filth in the same product. The lot is also rejected if:

(3) more than three species of stored insect pests are present
(4) live infestation is present
(5) several types of filth are present, the cumulative effect of which, is considered unacceptable. Experience is used to judge how many and what levels are excessive.
(6) If the extraneous material present is judged to be capable of causing physical harm, injury, sickness or death, the product is ruled as unacceptable, the above rules notwithstanding.

Examples of acceptable, marginally acceptable and unacceptable lots are presented in Table 8 using the guideline for insect fragments in rice where:

n = 3
c = 1
m = 25 insect fragments /100 g rice
M = 50 insect fragments /100 g rice

TABLE 8

NUMBER OF INSECT FRAGMENTS IN RICE TO ILLUSTRATE THE HPB GUIDELINE

	Analytical Unit #1	Analytical Unit #2	Analytical Unit #3
Case #1	25/100g	25/100g	25/100
Case #2	25/100g	25/100g	50/100g
Case #3	25/100g	50/100g	50/100g
Case #4	25/100g	25/100g	100/100g

In case #1, the lot is considered acceptable because each of the three analytical units does not exceed m = 25 insect fragments/100g.

In case #2, the lot is considered marginally acceptable because analytical unit #3 is marginally acceptable. It equals but does not exceed the value for "c".

In case #3, the lot is considered unacceptable because two of the analytical units are marginally acceptable. They exceed the value for "c".

In case #4, the lot is also considered unacceptable because one of the analytical units (#3) exceeds the value for "M".

The guideline for rice also includes values for whole and equivalent whole insects and rodent hairs. The total guideline reads as follows:

	n	c	m	M
whole or equivalent whole forms of insects	3	1	1/100g	3/100g
insect fragments	3	1	25/100g	50/100g
rodent hairs	3	2	0/100g	3/100g

Results and ratings for these three types of extraneous matter in white and brown rice analyzed by the Health Protection Branch from 1983-1988 are presented in Tables 9-11.

TABLE 9

WHOLE OR EQUIVALENT WHOLE FORMS OF INSECTS IN RICE

Analytical unit #1	Analytical unit #2	Analytical unit #3	Rating*
0	0	0	A
1	0	1	A
1	1	1	A
1	2	1	M
1	0	3	M
2	0	0	M
3	1	1	M
0	5	3	U
0	4	2	U
1	4	2	U
0	1	4	U
2	2	2	U
4	1	1	U
0	5	0	U
3	1	3	U
0	2	2	U

Analytical Unit = 100g
* A = Acceptable
M = Marginally Acceptable
U = Unacceptable

TABLE 10

INSECT FRAGMENTS IN RICE

Analytical unit #1	Analytical unit #2	Analytical unit 3	Rating*
15	24	25	A
24	25	22	A
22	21	25	A
7	33	10	M
49	18	20	M
43	24	19	M
0	72	12	U
40	27	0	U
71	25	14	U
37	27	30	U

Analytical Unit = 100g
* A = Acceptable
M = Marginally Acceptable
U = Unacceptable

TABLE 11

RODENT HAIRS IN RICE

Analytical unit #1	Analytical unit #2	Analytical unit #3	Rating*
0	0	0	A
0	2	0	M
0	3	2	M
1	0	1	M
3	0	1	M
0	1	2	M
4	1	1	U
0	3	4	U
2	2	1	U
0	5	0	U
3	1	1	U

Analytical Unit = 100g
* A = Acceptable
M = Marginally Acceptable
U = Unacceptable

6. TECHNIQUES FOR DETECTION

The procedures for detecting extraneous matter depend largely upon the type of food and the nature of the contamination that may be found. The first procedure is to examine the food macroscopically, that is with the naked eye or at up to 5x magnification.

It is important for quality control personnel to visually inspect food at all stages of processing and storage so that if contaminants are found they can be treated or eliminated as soon as possible. Often inspectors can only examine a food at one stage during the operation and may not see even a grossly unsanitary product because the contaminant was finely ground or very diluted. If such a problem is suspected, samples should be taken to a laboratory where the extraneous matter can be extracted and analyzed microscopically.

Health Protection Branch methods are listed in Table 12. Sources for other methods include the following:

1. Association of Official Analytical Chemists (AOAC) - light and heavy filth (Horwitz, 1984)
2. Food and Drug Administration (FDA) - macroscopic filth (Gorham, 1977, 1985; Centre for Food Safety and Nutrition, 1984)
3. American Association of Cereal Chemists (AACC) - extraneous matter in grain and grain products (AACC, 1983; Bauer,1985)
4. American Spice Trade Association (ASTA) - macroscopic filth (ASTA, 1976)
5. British Methods - macroscopic and light filth (Hanson, 1973; Thind and Griffiths, 1979)
6. Codex Alimentarius Commission - macroscopic filth (Joint FAO/WHO Food Standards Programme, via Terme de Caracalla, Rome)
7. International Organization for Standardization (ISO) - macroscopic filth (Switzerland)

Macroscopic Detection

a) Naked Eye

This is the most frequent method used by inspectors and quality control personnel examining food on arrival, during processing or during storage. It is important to recognize the variations that a sound food can have before making a judgement as to whether it is contaminated or not.

When samples are taken to the laboratory for visual analysis, the external surface of a selected number of units such as seeds, beans, fruit are examined for defectives such as the presence of insects and mites or their damage, adhering sand or soil, and mould etc. Often it is necessary to take scrapings of the contamination, to transfer them to a glass slide and to examine them with a microscope for confirmation. After examination of the external surface, the seeds etc. may be cut in half and the internal surfaces examined for defectives. Detailed procedures for visual analyses are given in some of the Health Protection Branch Methods (Health and Welfare Canada, 1989) listed in Table 12, for example, coffee beans, cocoa beans and nutmegs.

b) Magnifying Lens at 3-5x

For contamination that is just barely visible to the naked eye, a magnifying lens is useful. It is important to have good illumination on the product in order to clearly see the defectives. Examples of such defectives are mites on cheese (Plates 3 and 4), mites on fig paste (Plate 5), insects in figs, and mould in crevices of nuts. It may also be necessary to confirm the type of contamination microscopically by transferring some of the material in question to a glass slide and examining it with a microscope.

c) Dry Sieving

When food particles are small or when there is a variety of sizes, it is advantageous to separate the food into different particle sizes by shaking it through a nest of sieves. Usually three but as many as ten may be nested together. The mesh size of each sieve depends on the size of the food particles. The largest sieve is placed on the top down to the smallest one on the bottom. Food is shaken through the sieves for a specified period of time and then the contents of each sieve are examined. By separating the particle sizes, it is much easier to detect large pieces of extraneous material on the coarser sieves and small pieces on the finer ones.

d) X-ray Examination

The primary advantage of x-rays is that they can be used to detect areas of contamination in a non-destructive way, that may be overlooked by standard macroscopic methods. Specific applications include insect infestation in grains and bone fragments in mechanically separated meat.

Specific techniques for x-ray examination are outlined in the FDA Technical Bulletin #1 (Gorham, 1985) and #5 (Centre for Food Safely and Nutrition, 1984). If the particles examined with x-rays are kept anchored in place, suspect particles can later be removed and dissected at 10x magnification to verify the radiographic results.

e) Ultraviolet Examination

Longwave ultraviolet light (about 366nm) is often used to inspect foods or packaging for urine contamination that may not be visible in ordinary light. Inspection is done in a darkened room. In most cases, urine spots fluoresce white or green. They can be marked and sent to a laboratory for chemical identification. It should be noted that other substances may also fluoresce such as lubricating oils, printing dyes used on packages, detergents, aflatoxins and some insect faeces. Fluorescence, therefore, is only an indication of contamination and must be confirmed with other evidence such as rat, mouse, insect or other activity and chemical analysis.

f) Candling

Candling is a visual technique for determining the presence of glass and other extraneous matter in bottled drinks. Safety glasses should be worn for protection from glass explosions and bright light during examination of carbonated bottles. A bottle is held in a upright position in front of a strong light source and slowly rotated while the liquid is examined. The neck is then examined for discs of mould and paint chips. The bottle is swirled gently while still in an upright position and the bottom watched for movement of mould, yeast, dust, dirt and fibres. Then the bottle is gently tilted and the neck and shoulders examined for falling glass particles. Falling times vary with size and shape. If glass particles are suspected, samples are taken to the laboratory where contents of the bottles are filtered and analyzed microscopically or chemically.

g) **Organoleptic Examination**

With experience it is often possible to smell some types of contamination such as mouldy coffee beans, and mite or rodent infestations. The chewing activity of some insects such as carpenter ants can be heard. Organoleptic examinations should be confirmed with visible or chemical tests.

Microscopic Detection

In this type of detection, extraneous material particles are separated from the food and examined with a dissecting or compound microscope. The majority of foods examined by microscopic analysis are processed or ground foods or those already suspected of being contaminated. Since it is particulate matter that is sought, separation techniques are based on physical rather than chemical properties. The methods usually consist of three stages: pretreatment, extraction and recovery.

a) Pretreatment

Pretreatment is the preparation of a food for extraction by one or a combination of the following:

(i) defatting by boiling or simmering in an organic solvent (e.g. AOAC method 44.125, Horwitz, 1984) or by washing with a detergent followed by wet sieving (HPB method ExFHPB-1, alimentary paste products, 4.3.5). Defatting reduces the amount of fats or oils in the food so that it does not float up into the oil layer with filth elements during extraction. If the material is defatted too much, filth elements are also defatted and their recovery is reduced.

(ii) digestion by HCl (HPB method ExFHPB-1, alimentary paste products, 4.3.1-4.3.3) or by an enzyme (AOAC method 44.025, Horwitz, 1984) to disperse the food.

(iii) sieving: wet (AOAC method 44.005a, Horwitz, 1984) or dry (see Macroscopic Detection #3), to reduce the amount of product to be analyzed.

(iv) deaeration by boiling (AOAC method 44.126a, Horwitz, 1984) or by drawing a vacuum on the food dispersed in an aqueous medium to prevent flotation of excessive amounts of food.

(v) cooling to help decrease the amount of floating food (AOAC method 44.126a, Horwitz, 1984). Too much cooling depresses filth recovery.

b) Extraction

Extraction is the separation of the extraneous material elements from the food.

(I) Light Filth

The food is dispersed in an aqueous medium (water, water-alcohol). An oil is added and stirred through the aqueous medium. As the oil droplets rise to the top of the aqueous phase they carry many of the filth elements (insect fragments, hairs, etc.) that are lipophilic and insoluble in most reagents used in the extraction. A wetting agent (such as tetrasodium EDTA + Tween-80) may be added to the aqueous phase to help the food settle more readily.

The two most common sets of apparatus for extraction of light filth are the trap flask (Plate 6) and the percolator (Plate 9). Methods using both of these are described in detail as follows:

TRAP FLASK

The HPB method ExFLP-14 for light filth in dates is used. All glassware and sieves should be rinsed with

water to remove dirt, hairs and other extraneous matter that may have entered during storage.

1. 100 g of dates or date material is placed in a 1 L beaker. It is easiest to weigh the 100 g directly into the 1 L beaker but if the material was weighed on something else, be sure to wash the residue left on the weighing container into the beaker with a spray of warm water from a wash bottle to ensure that all material has been transferred.

2. Add 400 mL of hot (50-70°C) tap water and a magnetic stirring bar (1 x 5 cm or larger).

3. Bring the mixture to a boil with magnetic stirring. Boil until the mixture is finely dispersed (30-45 min. for pressed dates and 30 min. for sliced, chopped or macerated dates). This step allows the material to become finely dispersed without changing the extraneous matter. It also helps deaerate the date material so it does not float to the top during the oil extraction step.

4. Transfer the mixture to a #140 sieve. Wet sieve the date material with hot (50-70°C) tap water. The method for wet sieving is to pour a small amount of material onto the sieve and hold it at a 30° angle. Let a moderate spray of tap water wash the contents. Increase the pressure of the spray to achieve maximum spray action on the sieve but not so violent that the material froths near the top of the sieve or splashes out. Keep the material near the lower edge of the sieve and wash until the water runs freely through the material and the discard water is clear. Add more date material and wet sieve again until the discard water is clear. Continue to wet sieve until all the date material is washed. Rinse the inside of the beaker several times with hot water and pour onto the sieve to ensure that all material has been transferred. The wet sieving step helps to reduce the amount of fine material that may interfere with subsequent trapping.

5. Place a large funnel (15 cm top diameter) in the neck of a 2L trap flask. A trap flask is an Erlenmeyer flask containing a threaded rod attached to a large stopper (trap rod) (Plate 6). Make sure the trap rod comes through the neck of the funnel. Transfer the material in the sieve to the flask with a strong stream of water from a wash bottle. Rinse the bottom and the sides of the sieve and transfer rinsings to the trap flask. Repeat at least three times. If material adheres to the sieve, clean with a rubber policeman and transfer material to the trap flask with a stream of water. Note that each time material is transferred from one container to another, such as the sieve to the trap flask, it is necessary to ensure a quantitative transfer. Immediately back wash and rinse the sieve with a strong spray of water to ensure no material dries or adheres to the surface.

6. Carefully add a magnetic stirring bar (1x5 cm) to the liquid by lowering it down the inside wall of the trap flask. Avoid splashing the liquid. Bring the volume in the trap flask to 900 mL with deaerated water. Add the water slowly to avoid splashing because air may become entrapped in the plant material, float to the top and interfere with the extraction. The use of fresh tap water rather than deaerated water can result in 2-5x as much floating plant material in the extraction. Slowly add 50 mL of kerosene down the trap rod so the liquid does not splash.

7. Slowly bring the stirrer to maximum speed that does not produce audible or visible splashing or a permanent emulsion. All of the material should be in suspension and a portion of the stirring bar should be visible at the bottom of the vortex. Stir magnetically 5 min.

8. Slowly add deaerated water down the trap rod, maintaining the top of the stopper just above the kerosene layer. When the stopper is almost fully raised, continue adding water until the kerosene layer passes the stopper and the bottom of the kerosene layer is approximately 1 cm above the top of the fully raised stopper.

9. Swirl the stopper through the lower portion of the trap flask so as to suspend the settlings.

10. Let the mixture stand for 30 min. with intermittent stirring of the bottom layer during the first 20 min. (Plate 7). Do not disturb the oil-water interface.

11. Spin the stopper to remove sediment. Raise the stopper as far as possible into the neck of the flask, being sure that the oil layer and at least 1 cm of liquid below the interface are above the stopper. Pour off the liquid into a 1 L beaker. This step is called trapping off (Plate 8).

12. Rinse out the material on the rod and in the neck of the flask with water from a wash bottle and add to the beaker.

13. Lower the rod gently without losing any of the liquid by sudden splashing especially when the stopper is stuck within the neck of the flask.

14. Prepare a suction filtration apparatus with a Hirsch or Buchner funnel. Place a ruled filter paper (S&S #8) which is larger than the funnel plate on the funnel so the paper forms a cup. Moisten the paper with water and make sure its placement gives good suction before filtering. With water and then with alcohol from wash bottles, quantitatively transfer the contents of the beaker onto the identified ruled filter paper cup while filtering with suction. Do not allow the liquid to accumulate on the filter paper. Transfer the filter paper to a petri dish and moisten the paper with 1-2 mL of clearing agent (glycerol-alcohol (95%)(1:1)) (Plate 13).

15. Add 35 mL of kerosene to the trap flask.

16. Hand stir with a vigorous rotary as well as an up and down motion for 1 min. to disperse the kerosene throughout the mixture. Add enough water to bring the interface 1 cm above the fully raised stopper.

17. Let the mixture stand for 30 min. with intermittent stirring during the first 20 min. Some of the date material may have to be coaxed down with the stopper of the trap rod.

18. Spin and raise the rod to the highest position as before. Rinse the rod with water and then with alcohol.

19. Trap off into a beaker as in step #11, rinsing the neck of the flask with water and then with alcohol.

20. With water and then with alcohol from wash bottles, quantitatively transfer the contents of the beaker onto a second identified ruled filter paper cup as in step #14. Moisten the paper with 1-2 mL of clearing agent. The papers are now ready for microscopic examination.

PERCOLATOR

The HPB method ExFHPB-1 for extraneous material in alimentary paste products is used. All glassware and sieves should be rinsed with water to remove dirt, hairs and other extraneous matter that may have entered during sitting.

1. Weigh 100 g of alimentary paste into a 2 L beaker. For spaghetti, break into lengths that will not lie flat on the bottom of the beaker. If large amounts of spaghetti lie on the bottom they may not be completely digested.

2. Add 1 L of HCl (30 mL concentrated HCl + 970 mL water), 0.3 mL of antifoam solution and cover with a lid. Set the beaker in a larger container in case of breakage.

3. Autoclave for 30 min. at 121°C. Caution: check autoclave periodically for corrosive damage.

4. Wet sieve on a #230 sieve with hot (50-70°C) tap water to remove all original liquid and a major proportion of the fine material. Refer to Step #4 of the trap flask method for proper sieving technique.

5. If there is any fat material remaining on the sieve, visible as oil or fat droplets, defat as follows. Place the sieve in a shallow pan, cover the residue to a depth of approximately 2 cm with hot (50-70°C) detergent (1% sodium lauryl sulphate), leave for 5 min., drain and wet sieve with hot (50-70°C) tap water until all the suds have washed through. Be careful not to allow the suds to foam over the sides of the sieve. Repeat the defatting procedure at least once more until all visible fat has been removed.

6. Transfer the sieve retainings to the original beaker with hot (50-70°C) water. Rinse at least 3 times to ensure a quantitative transfer and dilute to approximately 1 L. Add 30 mL of concentrated HCl, a magnetic stirring bar (1 x 5 cm) and 50 mL of mineral oil.

7. Stir magnetically at maximum speed that does not produce visible or audible splashing for 6 min.

8. Promptly transfer the contents of the beaker to a percolator (Plate 9) containing approximately 250 mL of water. Rinse the contents of the beaker at least three times into the percolator with hot tap water making certain to transfer all material including heavy filth. Bring the volume in the percolator to 1700 mL with hot tap water (Plate 10).

9. Using wash bottles, rinse magnetic particles from the stirring bar into a beaker first with water, then with alcohol and finally with detergent until all particles are washed off. Filter washings through a ruled filter paper cup using a suction filtration apparatus as in the trap flask method (Step #14). Transfer the filter paper to a petri dish and moisten with 1-2 mL of clearing agent (glycerol:alcohol(95%)(1:1)).

10. After 3 min. drain the oil interface in the percolator to the 250 mL level into a 2 L beaker. Retain the contents of the beaker for heavy filth determination.

11. Refill the percolator by pouring hot tap water down the sides to loosen adhering material and refill to the 1700 mL mark.

12. After 2-3 min., drain the percolator to the 250 mL mark, discard the drainings and refill for 2 more cycles. The lower layer should be almost free of suspended material after the last refill. If not, continue through one or more recycles.

13. Finally, drain the oil-water interface to the 250 mL mark and drain the remaining contents into the original beaker. Promptly, using wash bottles, wash down the sides of the percolator successively with ≥ 50 mL portions of hot tap water, alcohol and hot tap water into the beaker. Use detergent (1% sodium lauryl sulphate) if necessary.

14. Using suction filtration apparatus, filter the contents of the beaker through identified ruled filter paper with a minimum of 50 mL washes of hot water, alcohol and water or detergent. Use a rubber policeman, if necessary, to clean the sides of the beaker.

15. Transfer the filter paper(s) to petri dish(es) and moisten with 1-2 mL of clearing agent. The plates are now ready for microscopic examination.

(ii) Heavy Filth

In a heavy filth extraction, the food is dispersed in an aqueous medium or organic solvent with a specific gravity that allows the food to float and extraneous elements heavier than the food such as sand, glass and excreta pellets sink to the bottom.

The HPB method ExFLP-14 for heavy filth in dates and date material is described.

1. Empty the remaining trap flask contents (from Step #19 of the light filth trap flask method) and wash portionwise through a #140 sieve. Wet sieve contents with hot (50-70°C) tap water until the rinsings are clear. Refer to Step #4 of the light filth trap flask method for the sieving technique.

2. Examine the sieve contents for pits and pieces of pit ≥ 2 mm. These can easily be felt with fingers (clean). Remove the pits and pieces of pit, measure, and count those ≥ 2 mm (longest dimension).

3. Transfer the remaining material from the sieve to a 1 L beaker and fill with water (Plate 11).

4. Allow the contents to settle 15 sec. and decant the upper portion, leaving the heavy residue of sand and soil etc. in the beaker.

5. Add more water and repeat the settling and decanting (Step #4) until all the plant material has been removed (Plate 12).

6. Using a stream of water from a wash bottle, quantitatively transfer the residue from the beaker to a preweighed oven-dried filter paper (Plate 14).

7. Examine the filter paper with a stereoscopic microscope at 30x magnification for particles of heavy filth.

8. Dry the filter paper in an oven and determine the tared weight in mg.

9. If there is appreciable filth (>75 mg), the filter paper and contents are ashed at 500°C. The temperature is brought up slowly so the filter paper does not burst into flames. It should just smoke slowly. The ashed material is cooled in a desiccator, weighed and the charring repeated 2 times to get a constant weight of inorganic material.

Heavy filth analysis of other products is done in the same way using water, saline solutions of various concentrations, chloroform or carbon tetrachloride. Although the latter two chemicals are flammable and toxic, their use is recommended since they give a cleaner separation of plant material from heavy filth and they do not disperse rodent and other excreta pellets.

(iii) Other Filth

Other methods for extraction of extraneous matter include the separation of magnetic metal particles from foods such as alimentary paste products (Step #9 of the light filth percolator method) or chocolate (HPB method ExFLP-16). Many extraneous matter methods also include analyses for mould such as the Howard Mould Count and rot fragment counts (e.g. HPB method MFO-5 for tomato products), ergot in grain particles (McClymont Peace and Harwig, 1982) and chemical methods for mould detection (Cousin, Zeidler and Nelson, 1984; Davies, Dennis and Grant, 1987, Lin and Cousin, 1985 and Lin, Lister and Cousin, 1986).

c) Recovery

Recovery is the filtration of extraneous material and the microscopic examination of the filter papers (Plates 13 and 14). Generally the papers are examined using a stereoscopic microscope at 30x magnification. Higher magnifications with a stereoscopic or compound microscope are used for confirmation of identification. Identification procedures are described in the next chapter.

TABLE 12

HEALTH PROTECTION BRANCH
EXTRANEOUS MATERIAL METHODS

COMMODITY	TYPE OF METHOD	ANALYTICAL UNITS PER SAMPLE	METHOD REFERENCE	ANALYTICAL TIME
Alimentary paste	Light filth Heavy Filth	3 x 225 g	ExFHPB-1	6-7 hrs/
Baby foods	Light filth Heavy filth Howard mould count	3 jars 3 x 10 g	FFAO 78/79	5-6 hrs/ sample
Bakery products without fruit and nut tissue	Light filth Heavy filth	3 x 100 g	ExFLP-22	6-7 hrs/ sample
Bean curd	Light filth Heavy filth	3 x 100 g	ExFLP-20	5-6 hrs/ sample
Beverages	Total filth	8 bottles 80/81	FFA4 sample	4-5 hrs/
Cheese (grated)	Total filth	3 x 225 g	ExFLB-10 sample	6-7 hrs/
Chocolate	Magnetic metal particles	3 x 100 g	ExFLP-16	6-7 hrs/ sample
Cocoa beans	Macroscopic filth	8 x 100 beans	ExFHPB-2	6-7 hrs/ sample
Cocoa powder	Magnetic metal particles	3 x 100 g	ExFLP-16	6-7 hrs/ sample
Coffee beans	Macroscopic filth	8 x 100 beans	ExFHPB-3	5-6hrs/ sample
Currants	See raisins			
Dates (whole)	Macroscopic filth	8 x 50 dates	ExFHPB-4	5-6 hrs/ sample
Dates (chopped, sliced, macerated, pressed)	Light filth Heavy filth	3 x 100 g	ExFLP-14	6-7 hrs/ sample
Fig paste	Light filth Heavy filth	8 x 100 g	ExFHPB-6	6-7 hrs/ sample
Flour (white, wheat)	Light filth Heavy filth	3 x 50 g	ExFLP-19	6-7 hrs/ sample

COMMODITY	TYPE OF METHOD	ANALYTICAL UNITS PER SAMPLE	METHOD REFERENCE	ANALYTICAL TIME
Fruit (dried)	Macroscopic filth	8 x 50 units	ExFLP-8	5-6 hrs/ sample
Fruit (glacé, crystallized)	Macroscopic filth Light filth Heavy filth	3 x 225 g	ExFLP-4	4-5 hrs/ sample
Legumes (dried, frozen, canned peas, beans, lentils)	Macroscopic filth	8 x 100 units	ExFLP-15	4-5 hrs/ sample
	Light filth	3 x 583 g		4-5 hrs/ sample
Meat (mechanically boned)	Magnetic metal particles, Bone fragments	3 x 225 g	ExFLB-11	4-5 hrs/ sample + overnight digestion
Mushrooms (canned, dried frozen, etc.)	Mites, maggots nematodes mould	6 x 100 g	ExFLP-17	4-5 hrs/ sample
Nuts (shelled and unshelled)	Macroscopic filth	8 x 100 nuts	ExFLP-9	5-6 hrs/ sample
Rice (white)	Light filth	3 x 100 g	ExFLP-21	3-4 hrs/
Rice (brown)	Light filth Heavy filth	3 x 100 g	ExFLB-13	4-5 hrs/ sample
Soya sauce	Total filth	3 x 1 bottle	ExFLP-12 sample	5-6 hrs/
Soyabean sauces (fermented)	Light filth Heavy filth	3 x 100 g	ExFLP-12	5-6 hrs/ sample
Spirulina, kelp and sea vegetation	Light filth	3 x 50 g	ExFLP-23	6-7 hrs/ sample
Tea (black)	Heavy filth	3 x 25 g	ExFLP-18 sample	5-6 hrs/
Tomato products	Howard mould count	3 x 50 g	MFO-5	3-4 hrs/ sample

7. IDENTIFICATION

General Technique

Most of the identifications of extraneous material are based on their microscopic properties. For routine examinations of light filth and metal particles, the filter paper and contents are moistened and cleared using a glycerol-alcohol (95%) solution (1:1) which should be applied immediately after filtration to prevent the material from hardening. This solution partially clears the plant material and helps the filth elements stand out against the white filter paper. Enough solution should be added to fill the fibres of the filter paper but not so much as to cause the filth elements to flow from one place to another. Clove oil may also be used. It clears the plant material more thoroughly but is considerably more expensive (10 times). For examination of heavy filth, the filter papers are moistened with water or 50% alcohol. Any plant material present is not cleared but rodent pellets and larvae are pliable and can easily be dissected for examination. Once the filter papers are moistened, they are pressed against the bottom of the petri dish, preferably using a probe, to get the paper to lie as flat as possible so that most of the material is in the same focal plane.

To examine the filth plate (filter paper), a stereoscopic microscope is used at 30x magnification. At this magnification, the field of view is approximately 5 mm which is the distance between two lines on the filter paper. Starting at one side of the filter paper and using the lines as a guide, examine the paper by going back and forth between the lines until the entire paper has been examined. Do not forget to examine the edges of the filter paper as filth often rises up the sides during filtration.

As each field is examined, filth and other particles can be turned over or moved with a probe for better examination. Questionable particles can be examined at higher magnifications of up to 60-70x. These magnifications are the upper limit of the resolution of a stereoscopic microscope using reflected light. The lenses of the microscope should be kept clean at all times to facilitate clear images. A strong even light source should be used. Sometimes a combination of reflected and transmitted light (from the bottom of the plate) help structures to be seen more clearly.

If the structures of a particle are still not clear enough to determine its identification, it can be examined with a compound microscope at 100-400x magnification. To do this, the particle is transferred with a probe or fine forceps to a glass or depression slide containing a small amount of mounting medium and covered with a cover slip. For temporary mounts, glycerol is a suitable medium. For permanent mounts, glycerin jelly (also called glycerol jelly) or malinol are the easiest and most satisfactory ones to use without having to clear or dehydrate the specimen. For mites, Heintz medium is recommended and for mould, Amann's mounting fluid. Because Amann's medium is a liquid, the edges of the coverslip have to be sealed with a medium that hardens such as Euparal, Balsam or nail polish. It is a good idea to seal slides made with all these mounting media to prevent dehydration of the material. Glyptol, an oil and moisture resistant electrical finish available from Canadian General Electric (G-1201), is recommended. It fixes in 2 hours and gives a good seal that lasts but it must be used in a fume hood.

A comparison microscope is also useful for identification of extraneous matter. A questionable particle is placed on one stage and a reference particle on the other one. They can be viewed at the same time and at the same magnification with one image on one side and the other beside it. This instrument is very useful for identification of hairs and of insects to species.

Generally extraneous material particles are identified and counted using a stereoscopic microscope. The approximate largest and smallest are measured using a micrometer disc in one of the microscope's eye pieces. Questionable particles and specific insects, mites, hairs etc. are identified using a compound or comparison microscope.

Several staining procedures are recommended to help count plates. Identifications should, however, be based on the structures of the fragments or parts, not on their staining properties.

Mites are often difficult to see on a plate because they are small, white and often shrivelled. They can be stained blue by adding methylene blue (1.0 g/L of water) to the contents of the extraction flask. Some plant material, however, also is stained blue and mite exuviae (cast skins) are generally not stained. Crystal violet (saturated aqueous solution) is used to stain mites, maggots and nematodes in mushrooms which are subsequently bleached with sodium hypochlorite. The mites etc. are blue and the mushroom tissue, white. Even though the mites are blue, one must check their shape and structures to confirm their identification before including them in a count. For products such as cocoa and cinnamon where fragments of food are almost the same colour as insect fragments, counting is made easier if the cocoa etc. is bleached (AOAC procedure 44.006-.007, Horwitz, 1984) after the plate has been examined for hairs.

Specific Identifications

a) Food Material

Before extraneous material particles are identified, it is important to have a good knowledge of the microscopic structure of food material. Useful references for identification of plant material are Wallis (1965) and Smith (1983).

b) Whole Insects

Whole insects are made up of a head, thorax and abdomen and have usually three pairs of legs (Figures 1-6). Their bodies are segmented and their cuticle or outer skin has a characteristic microstructure. Insects have various life stages. Those that undergo complete metamorphosis have four very different stages: egg, larva (Plate 15), pupa (Plate 16) and adult (Plate 17). Those that undergo incomplete metamorphosis have similar life stages of different sizes: egg, nymph and adult e.g. cockroaches. Insects can be identified to order i.e. flies, beetles etc., using the keys in Borror, Delong and Triplehorn (1981) for adults, Wilson et. al. (1984) for adults, larvae, and nymphs, and Peterson (1960, 1962) for larvae. The best identification key for stored product insect adults is that of Freeman (1980). Other useful references are Hinton (1945) and Aitken (1975) (beetles), Agriculture Canada (1981, 1987) (flies), and Metcalf, Flint and Metcalf (1962) and Ebeling (1975) (economically important insects).

c) Equivalent Whole Insects

One indication of the level of contamination in foods is the number of whole insects in a product. Because insects may become somewhat damaged or broken up during processing or handling, the term "equivalent whole insect" has been defined for counting insect parts so that they will neither be counted twice nor ignored. An equivalent whole insect must have the dorsal central part of the head present to be counted.

A whole or equivalent whole insect count includes the following:

(i) whole heads of adults, pupae and larvae of Coleoptera (Figures 7-11) and Lepidoptera (Figure 12).

(ii) partial heads of Coleoptera and Lepidoptera (adults, pupae and larvae) when more than one half of the head is present. These heads must include the entire frons as shown in Figures 7-12 (stippled areas).

(iii) whole and partial exuvial heads of Coleoptera and Lepidoptera. More than one half of a partial exuvial head must be present to be counted and must include the entire frons (Figures 7-12 (stippled areas)).

(iv) whole heads of adults, pupae and larvae of Diptera (Figure 13).

(v) partial heads of Diptera when more than one half of the head is present. For Diptera adults these heads must include the entire frons (Figure 13 (stippled area)). For Diptera larvae (maggots) and pupae these heads must include the entire mouth hook (Figure 13 (stippled area), Figure 14).

d) Insect Fragments or Parts

Insect fragments or parts are identified by their characteristic shape and by the fact that the cuticle has specific diagnostic features such as setae, setal pits, sculpturing and sutures as outlined in Table 13. In Table 14, features are listed to differentiate insect fragments from plant fragments.

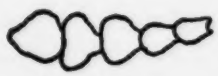
It is often possible to tell what group or species of insect is present by the structure of some of the fragments. Kurtz and Harris (1962) have described and photographed fragments of many food infesting insects. Other references for identification of insect fragments include Daly et. al. (1958), Ensminger (1958), Harris (1960), Heuermann and Kurtz (1955), Jackson et. al. (1956), Kurtz (1956), McClymont Peace (1985), Sabatino (1954) and Thrasher and Kurtz (1957).

TABLE 13

RECOGNITION OF INSECT FRAGMENTS
(from Vasquez, in Gorham, 1977b)

Insect cuticle has certain universal characteristics. A suspected particle can be identified as of arthropod origin if it has any one of the following characteristics:

1. The readily recognizable shape of a whole or a portion of a specific appendage or body part.



2. An articulation or joint.

3. One or more setae arising from a pit.Setae must not have a cellular structure.

4. One or more setal pits.

5. Surface sculpture characteristic of a specific insect or part thereof. Do not be fooled by "sculpted" seed coats.

6. One or more sutures.

Characteristics that can help form one's opinion as to the insect origin of a particle but are not in themselves conclusive:

1. Flexibility and toughness.

2. Thinness.

3. Lustre.

4. Lack of cellularity. Surface pattern may resemble cells but usually will be a repeating pattern of identical units. Cellular structure of plant material will show more individual variation.

5. Setae never septate (divided by cell walls) and never appear to be composed of several cells. Plant hairs are frequently multicellular.

TABLE 14

COMPARISON BETWEEN INSECT FRAGMENTS AND PLANT FRAGMENTS EXAMINED AT 30 - 60 x (Gecan and Brickey, 1967)

INSECT FRAGMENTS	PLANT FRAGMENTS
TEXTURE	
1. Fragments usually platy spongy.	1. Fragments usually thick and never spongy.
2. Fragments usually flexible but not easily torn apart.	2. Fragments easily torn apart.
LUSTRE	
1. Fragments always lustrous.	1. Fragments never lustrous.
CELLS	
1. True cells not visible.	1. True cells usually visible.
2. Surface pattern (sculpturing) may resemble cells, but these are arranged in geometric design of identical units.	2. Arrangement of cells usually irregular and show individual variation.
SETAE - HAIRS	
1. Setae sometimes present.	1. Hairs sometimes present.
2. Setae never multicellular; attached to ring-like base.	2. Hairs multicellular. Occasional unicellular and stellate hairs from other sources.
3. Setae usually attached to fragment.	3. Hairs rarely attached to fragment.
SCULPTURING	
1. Sculpturing usually present.	1. Sculpturing never present.
SUTURES	
1. Sutures sometimes present.	1. Sutures never present.

Mandibles are often used for specific identifications because they are hard, dark and often recovered intact from foods. They have many diagnostic characters. For example, left mandibles are different than right (Plate 18). Within each species, adult mandibles are different than those of the larva and pupa. Those of nymphs are similar but not identical to those of the adult. Sometimes male mandibles are different than those of the female. A useful key with diagrams for the identification of insects based on the structure of the mandibles is given by McClymont Peace (1985).

It should be emphasized that once a fragment or mandible has been keyed to a specific name, other parts of the insect or associated fragments should also be checked to make certain they match the same species because closely related insects can be similar but not identical. The material should be checked in Kurtz and Harris (1962) and with authentic reference material of stored product insects where identifications have been made, based on the whole specimen and by a recognized authority. Whole insects can be sent to Agriculture Canada or provincial governments for identification. Reference material is difficult to obtain unless collected by oneself, but some is available from government agencies e.g. Agriculture Canada, FDA, from universities and from some pest control companies e.g. Abell Waco Ltd., Toronto.

e) Insect Excreta

Wherever insects are present, so is their excreta. Insect excreta contains both uric acid (also found in bird excrement) and chitin. Uric acid can be identified by spectrophotometric tests (AOAC 44.189-.193, Horwitz, 1984) or by TLC (AOAC 44.186-.188, Horwitz, 1984). Chitin can be converted to chitosin (with 23 M KOH at 121°C.) which stains violet with the addition of IKI (Roelofsen and Hoette, 1951). High concentrations are needed to detect chitin in excreta. Webbing left by Lepidoptera larvae, spiders and some mites can be detected by tests for silk i.e. its microscopic structure in conjunction with a chemical test. Silk dissolves in 10% HCl as well as in 5% KOH in 10 minutes at room temperature.

f) Mites

Mites are arthropods more closely related to spiders and crabs than to insects. They are recognized by their small (100-400μm) oval body, their pointed snout with no visible head and four pairs of legs in the adult and nymphal stages (Plates 1 and 2, Figure 15). Larval mites have only three pairs of legs. Mites are difficult to identify to species until an analyst is familiar with their structures. All identifications should be made at 400x or more using a compound microscope. The most useful reference for identification is Hughes (1976). Boese (1977, 1978) lists other useful references. Mites can be sent to the Biosystematics Research Centre, Agriculture Canada, Ottawa, K1A0C6, for identification.

g) Nematodes

Nematodes are often found in mushrooms and sometimes in other vegetables. Identification can be checked in Gorham (1985) or almost any parasitology textbook. Nematodes can also be sent to the Biosystematics Research Centre, Agriculture Canada, Ottawa, K1A0C6, for specific identification.

h) Hairs

Hairs must be identified with a compound microscope. Important features to examine are the size and shape of external scales, the size, shape, colour and distribution of pigment granules and the shape of medullary structures. Important references are Vasquez (1961), Gorham (1985), Appleyard (1978), Heyn (1954) and Lewis (1978).

In order to determine if hairs are of animal, plant or synthetic origin, microchemical tests can be done using the following key, if there are a few hairs to spare. Because the tests are destructive, microscopical

analysis should be done first.

1a. soluble in 5% KOH at boiling for 10 min.(animal hairs and silk).....2
1b. insoluble in 5% KOH at boiling for 10 min. (cellulose and synthetic fibres).....3
2a. soluble in 10% HCl at boiling for 30 min.....silk and most animal hairs except wool
2b. insoluble in conc. HCl.....wool and regenerated protein fibres
3a. insoluble in cuprammonium hydroxide*..... synthetic fibres
3b. soluble in cuprammonium hydroxide.....cellulose fibres
(Cotton fibres dissolve but the waxy cuticle (soluble in dilute NaOH) does not).

* Cuprammonium hydroxide = cuoxam (0.5 g calcium carbonate + 10 mL water + 10 mL ammonium hydroxide.

Important microscopic structures of hairs commonly found in foods are as follows:

Human hairs (Figure 16) have fine scales (S), fine pigment granules (P) that range from colourless through brown to black and a discontinuous medulla (M).

Sheep hairs (wool)(Figure 17) have more coarse scales (S) and larger pigment granules (P). They may also be dyed.

Goat hairs (Figure 18) have a wide cortex band (C) and appear longitudinally striated. The medulla (M) is wide, continuous and made up of lens-shaped chambers.

Mouse hairs have a striped or striated appearance because of pockets of pigment in the medulla. Mouse fur hairs (Figure 19) have strictures (ST), I-beamed air cells (I), cortical pegs (CP) and pigmented medullary cells (M) where the distal ends are wider than the proximal ends. Guard hairs (Figure 20) have more than three rows of medullary cells (M) and a very clear unpigmented cortex (C). Mice also have other hairs: tylotrichs, awls and auchenes ,Vasquez (1961). These are less numerous and made up of structures present in both fur and guard hairs.

Rat hairs are similar to mouse hairs but much larger. Gorham (1985) and Vasquez (1961) outline the differences.

Rabbit fur hairs (Figure 21) are similar to those of mice and rats but lack strictures. They can, however, be wavy and somewhat narrowed. Rabbit guard hairs (Figure 22) are similar to mice and rat hairs except they are cross-, H- or dumb-bell shaped in cross section rather than round or oval and the medullae (M) have intrusions of cortical material into their sides.

Squirrel fur hairs (Figure 23) are also wavy but have no strictures. The cortex is often longitudinally striated. They have no cortical pegs nor I-beam-shaped air cells. The air cells (A) are oblong or concavo-convex. Squirrel guard hairs (Figure 24) are also similar to mice and rat hairs except that the cortex (C) may appear longitudinally striated and the pigment granules (P) are more elliptical.

Dog hairs (Figure 25) are often wavy and have a thick cortex (C) with fine oval pigment granules (P). There is a lot of variation in dog hairs and some look like those of a cow.

Cat hairs (Figure 26) are similar to dog hairs and are variable. Some have rifle-pellet-shaped medullary cells (M).

Bat hairs (Figure 27) are very thin and have no medulla. They are covered with coarse divergent scales (S) and superficially resemble feather barbules.

Feather barbules (Figure 28) are branched and have pockets or waves of pigment (P). The barbules may be widened at the areas of pigment or they may be tapered.

Wheat hairs (Figure 29) have no scales and very little internal structure. They are always tapered.

Insect setae may be simple, usually of uniform colour, branched, plumose, spatulate or very ornate as in some Dermestidae larvae (Figure 30).

Synthetic fibres such as nylon (Figure 31) are very uniform in width and structure. They often contain dark irregularly spaced granules of titanium dioxide (T) used to deluster the fibres. Most synthetic fibres such as nylon polarize light, unlike animal hairs.

Mould filaments (Figure 32) may also appear similar. They generally do not polarize light as well as synthetic fibres. They have parallel walls (PW), branching (B), rounded tips (R) and sometimes granulation (G) and septation (SP).

Xylem tissue (fibrovascular bundles, Figure 33) are composed of clear parallel-walled and strongly coiled fibres.

i) Animal Excreta and Excrement

Mammalian urine can be detected by ultraviolet light, urease, xanthydrol, magnesium uranyl acetate, bromothymol blue or TLC (AOAC 44.163-.180; Horwitz,1984). Mammalian faeces can be determined by alkaline phosphatase (AOAC 44.181-.184; Horwitz, 1984). Rat, mice, cat and dog faeces can be partially identified by the size and shape of their excrement and the predominant type of hairs present in them because these animals often lick themselves and swallow their hairs.

j) Crystals and Heavy Filth Elements

Crystals can be identified by their solubility properties, refractive index and melting point, etc. To test a crystal for solubility, place it on a glass side, cover it with a coverslip and apply a drop of solvent to one side of the coverslip. A second solvent can be applied at the edge of the coverslip while the first is removed with a piece of filter paper at the opposite side. The range of solvents should include water, dilute acids and bases, and organic solvents of decreasing polarity. Observe the crystal for solubility, effervescence and colour change.

Ignition tests made on a piece of platinum will indicate whether a particle is organic or inorganic or a combination of the two. Usually the particle is contaminated. If the particle is pure, melting point and flame colour are important characteristics and may determine what subsequent tests should be done. Useful references for identification of crystals are Chamot and Mason (1958), Hartshorne and Stuart (1952), McCrone and Delly (1973), Lewis (1978), Wallis (1965) and Rutherford (1974).

Glass and clear quartz or other crystals appear similar when magnified. Glass can be differentiated by its ability not to polarize light, its refractive index, density and melting point. Quartz, on the other hand, polarizes light and has different values for the other characteristics. Most glass, sand and soil contain large amounts of silicon which is soluble in HF. Limestone, chalk and carbon are soluble in concentrated HCl.

Metal particles are dark or shiny and hard. Those resulting from shearing are often pointed and curled. Fragments of saw blades, cutters, stirrers, etc. generally show evidence of a fabricated shape with a fractured edge. Wire is uniform and cylindrical. Silver coloured dental fillings contain mercury which may ooze from the particle on heating. Ferrous metal, in the presence of HCl, produces hydrogen and a yellow solution that turns red with the addition of thiocyanate. Atomic absorption spectrophotometry and energy dispersive X-ray analysis can also be used for identification of particles. A useful reference for identification of metal particles is Lockwood (1934).

k) Miscellaneous Contaminants

Flakes of paint can be identified by their colour, multilayered structure, characteristic odour on burning and their elemental composition (iron, lead, zinc, silicon and titanium) by energy dispersive X-ray analysis.

Transparent packaging film and laminates can be identified by tests using heat, solvents and stains as outlined by Smith (1966). Tests for other plastics and rubbers are described by Saunders (1973). Aluminium foil dissolves in NaOH with the evolution of hydrogen. Smith (1983) describes a spot test for finger nails. A fragment is treated with concentrated nitric acid, washed with water, and then treated with ammonium hydroxide. The finger nail becomes orange coloured.

Greases and oils fluoresce under UV light and dissolve in hexane. They usually contain additives such as graphite, molybdenum sulphite or iron which can also be identified.

Shell from crabs or lobsters can be stained with alizarin red S after digestion as described in AOAC 44.079 (Horwitz, 1984).

8. GOOD LABORATORY PRACTICE

It is of utmost importance that an analyst be able to precisely follow the methods to be used. In order to accomplish this, one must have a good knowledge of the methods, equipment and safety procedures that are involved. The laboratory should be supplied with all necessary equipment which should be kept in good working order. All precautions should be taken to keep dirt and other foreign material out of the laboratory so samples are not additionally contaminated. The analyst should be able to continually update his/her skills where needed and be involved in a program to assure good performance.

Safety Procedures

Extraneous matter methods involve the use of a wide variety of toxic and flammable solvents, acids and bases. It is required by law that the analyst know and follow the safety procedures necessary to handle and dispose of these chemicals. It is essential to use a fume hood for most extraneous material extractions. Most chemical companies as well as industry and government can provide information on safety procedures.

Equipment

Balances, ovens, pH meters, refractometers and thermometers etc. should be in good working order and calibrated at least twice a year. Fume hoods must be in good working order and should be checked at least yearly. Usually fume hoods are checked by specialists but if not, smoke bombs can be purchased, lit and the pattern of smoke traced. Microscopes, especially the lenses, should be kept clean and should be of good quality because the analyst is often working at the upper limit of resolution.

Reduction of Contamination

It is important to keep particulate contamination out of the laboratory as much as possible so that samples are not further contaminated during analysis. The laboratory should be cleaned at least once a week. Glassware and other laboratory ware should be rinsed in clean water immediately before use to wash off any air-borne material that may have settled during storage. Sieves should be back-washed before use for the same reason. The water supply should be checked on a regular basis for particulate contamination as should most of the reagents used. Sometimes during heavy rains, suspended soil material or insects (aquatic) may enter the water supply and be extracted with the extraneous material elements. It is advisable, therefore, to use filtered or distilled water on a regular basis. The air supply into the laboratory should be clean and screens should be present on windows and vents for fume hoods etc.

Samples should be sealed in insect-proof containers such as heavy double plastic bags to prevent additional contamination during storage, transport or analysis. If live infestation is suspected, samples should be kept refrigerated or frozen until analysis to curb insect or mite activity. When working with infested samples, they should be placed in a tray or dish, surrounded by or floating in a larger container of glycerol or oil to contain moving insects or mites. They can swim in the oil but their movements are slowed down. Mouldy samples should be handled in a fume hood or laminar flow cabinet. After working with contaminated samples, the working area should be suitably cleaned and disinfected. Contaminated samples should be autoclaved and suitably disposed.

Reference Material

In order to properly identify extraneous material, it is essential to have a good collection of reference material. Much of the essential reference material can be collected with relative ease. For example, one can collect insects from warehouses during visits with an inspector or from outside, in the case of field insects. Mites can be collected from infested samples, from greenhouses, from house dust and from outside on plants or in the soil. Hairs can be obtained from one's head, from pets and from surplus hides in a museum or university. It is important to have a portion of each type of extraneous material mounted on glass sides in order to study and compare its microscopic structure with unknown elements. Whole insects can be dissected and the parts mounted on glass sides for study. It is important to prepare microscopic slides of food material as well so one is familiar with its microscopic structure. It is also essential to have a good collection of manuals, textbooks and journals. A basic set would be the publications marked with an asterisk in the reference section.

Training

There are very few courses offered in the field of extraneous material. Recommended ones include FDA workshops, University of Manitoba extraneous matter workshops (Dept. of Food Science, Winnipeg, Manitoba), AACC courses (3340 Pilot Knob Rd., St. Paul, MN, USA) and Kurtz Assoc. programs (P.O. Box 2725, Port Charlotte, FL, USA). It is advisable to become involved in various check sample programs such as those offered by the AACC and Kurtz Assoc. Generally they provide the analyst with a series of light filth plates naturally contaminated with insect fragments and hairs. The analyst is to transfer the contaminants to a gridded paper and identify the fragments as thoroughly as he/she can. The plates are then sent to and checked by a competent analyst who answers any questions or comments, notes false positives and transfers any fragments of insects or hairs that were missed. These check samples are individually geared to any level of expertise.

Any time a new method is used, it is recommended that one analyze a sample which has been artificially spiked with marked fragments of insects, mites and hairs or heavy filth to determine the recovery rate. For most types of extraneous material the recovery rate should be 90-100%.

Computers

Computers are often used for storage and retrieval of extraneous material data. Programs are being developed, particularly in the field of entomology, called expert systems for solving problems and making decisions (Coulson and Saunders, 1987). Perhaps similar systems could be developed for designing diagnostic tests for extraneous matter and for evaluating data.

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*highly recommended references

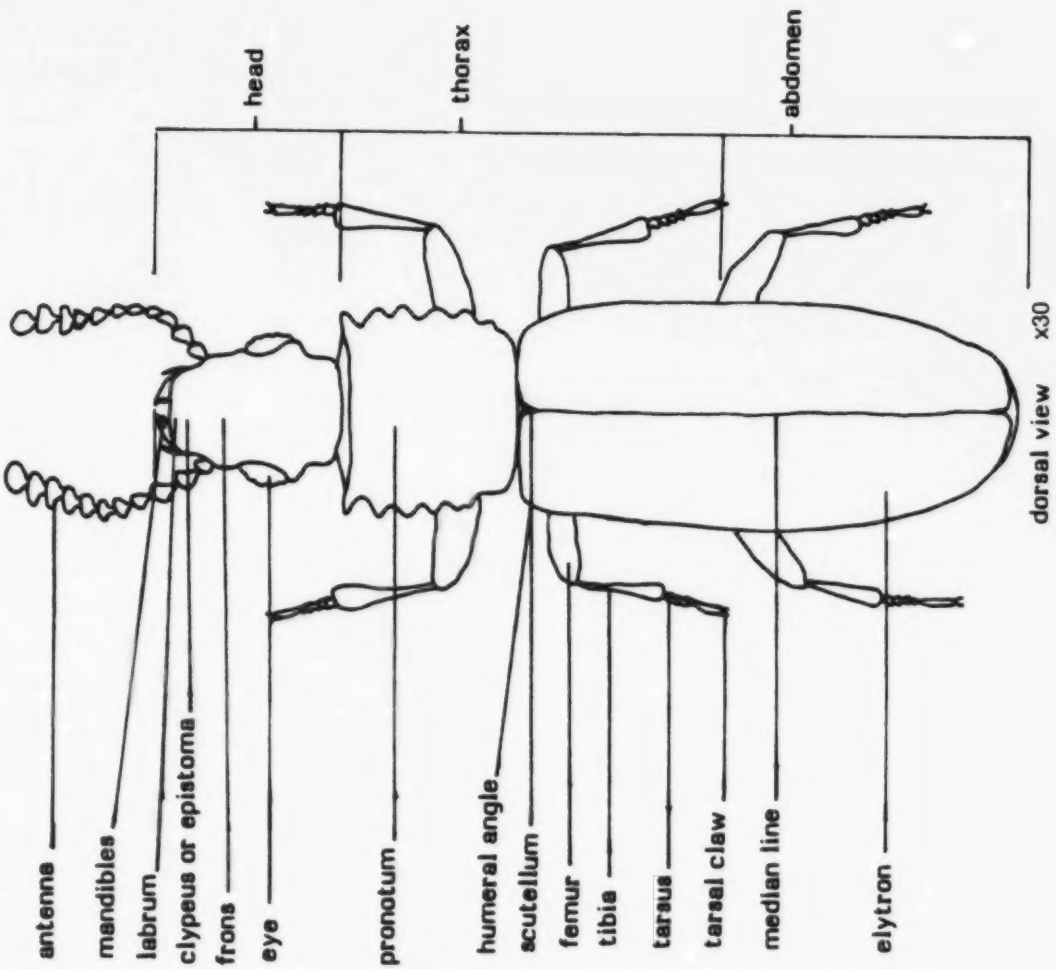


Figure 1. Parts of an Adult Coleoptera (beetle) (Oryzaephilus mercator)

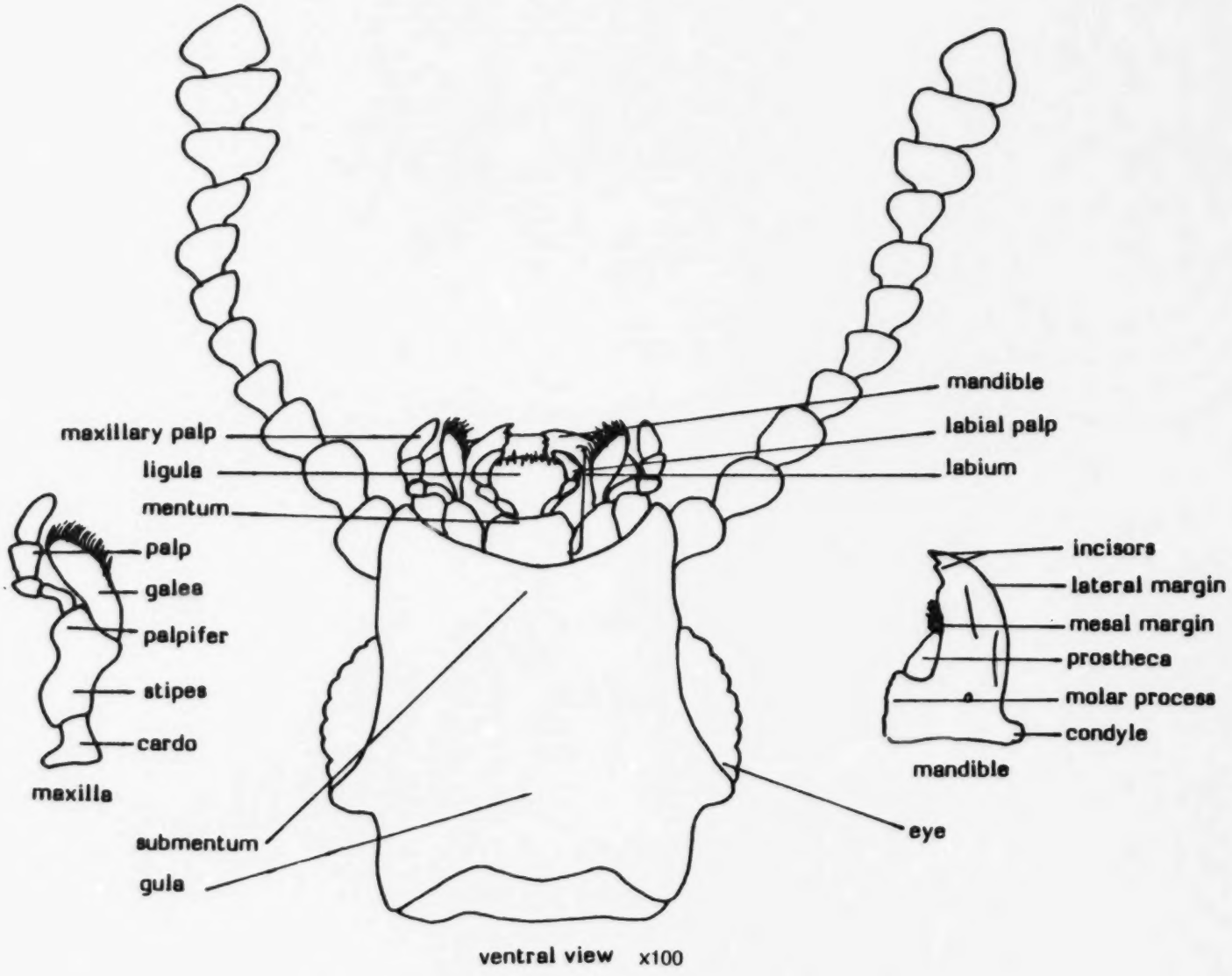


Figure 2. Parts of an Adult Coleoptera (beetle) Head

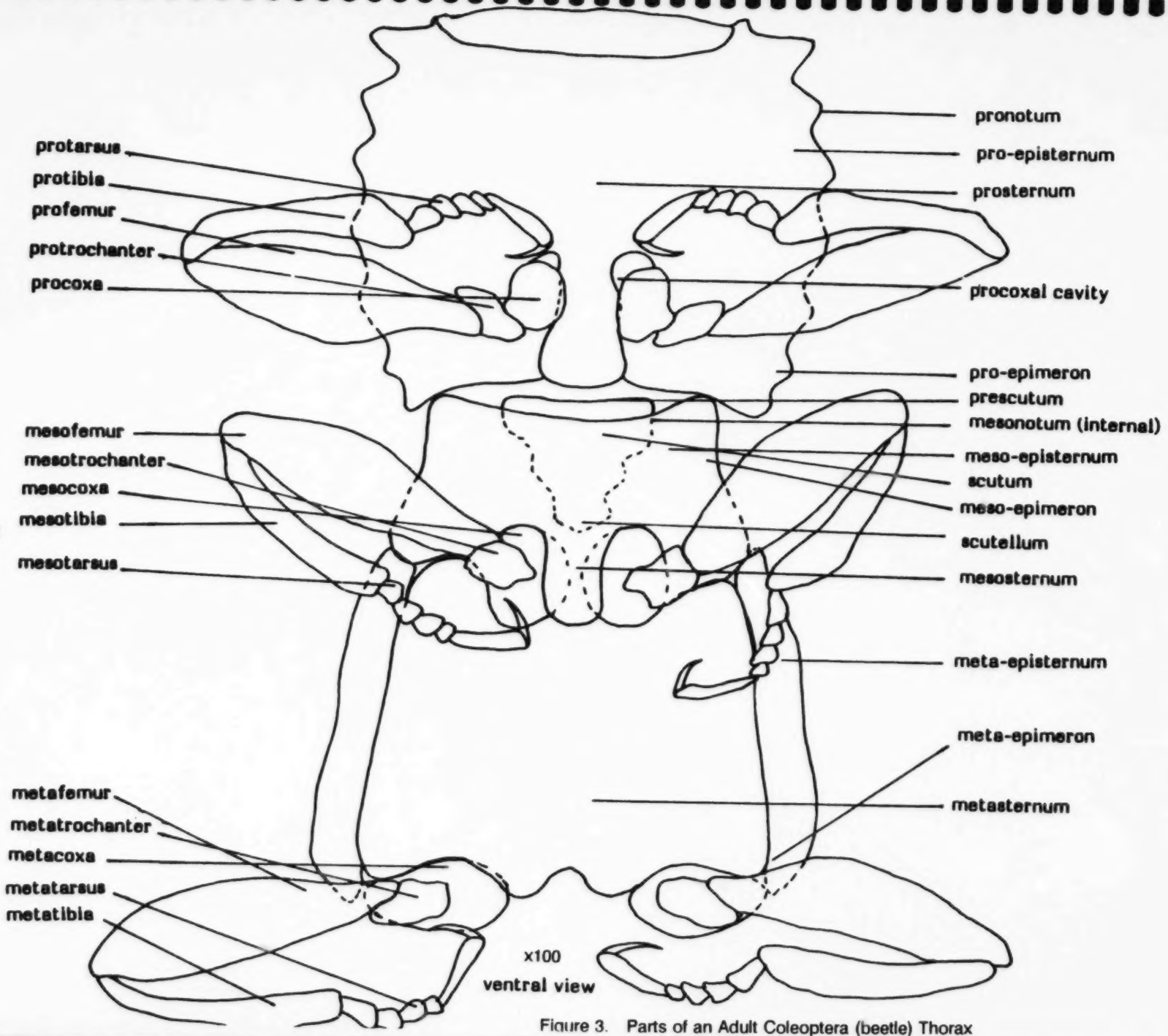


Figure 3. Parts of an Adult Coleoptera (beetle) Thorax

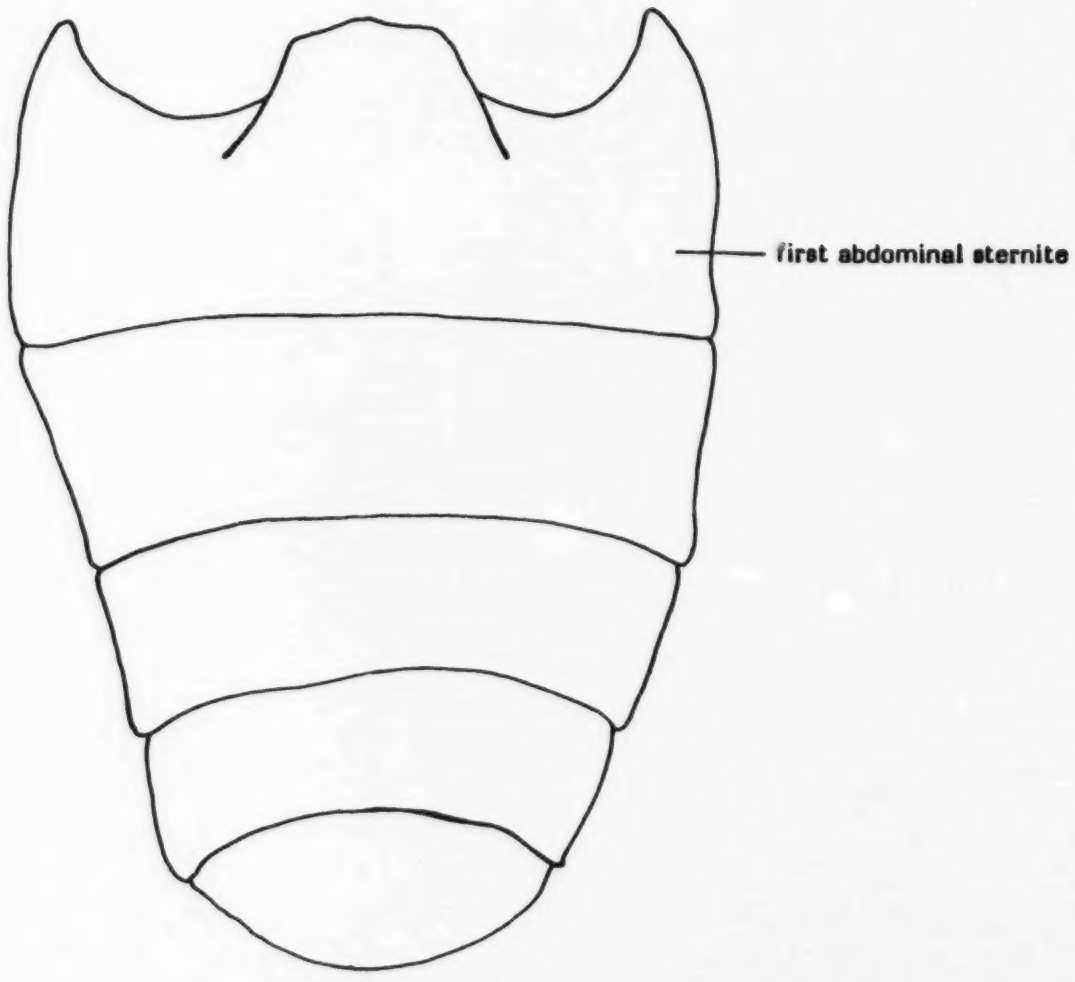


Figure 4. Parts of an Adult Coleoptera (beetle) Abdomen

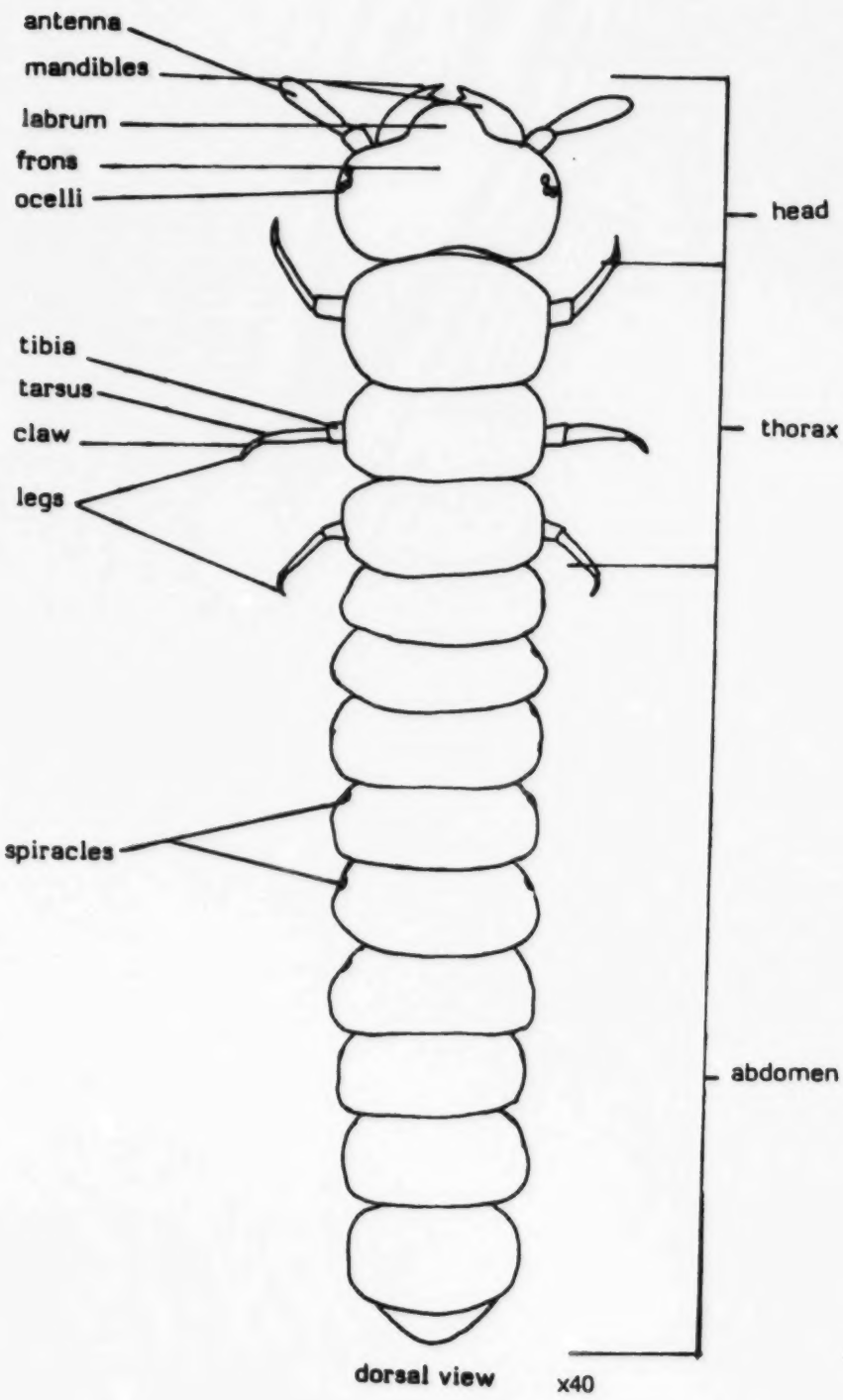
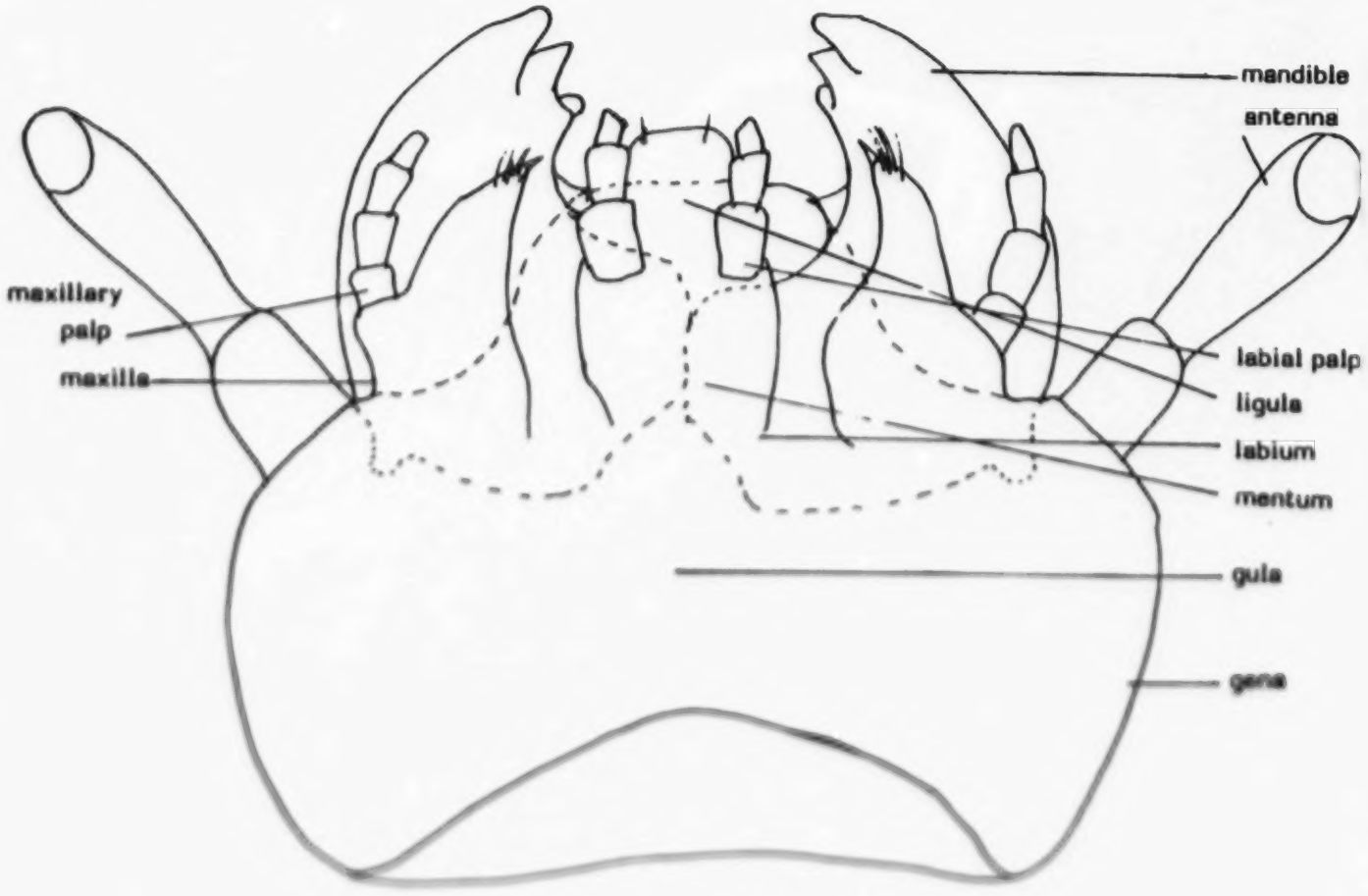


Figure 5. Parts of a Larval Coleoptera (beetle)



ventral view ×100

Figure 6 Parts of a Larval Coleopteran (beetle) Head

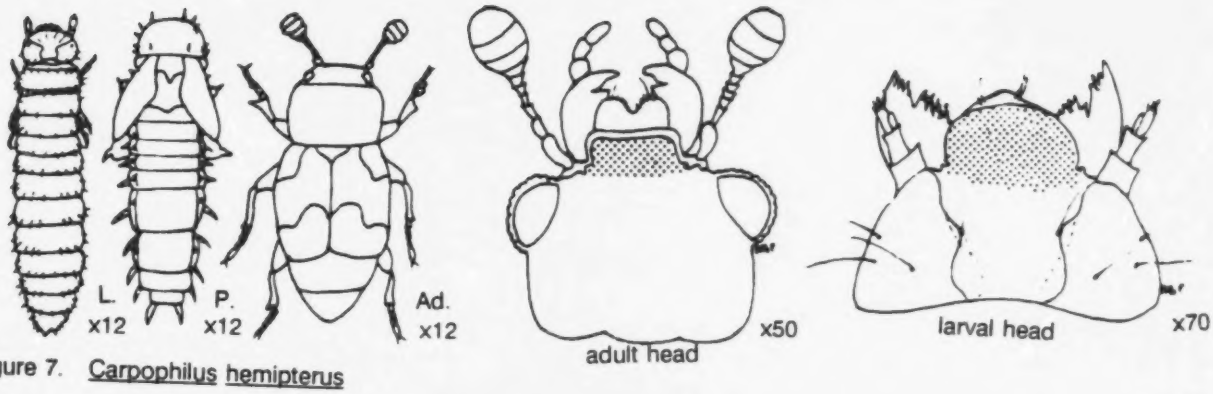


Figure 7. Carpophilus hemipterus

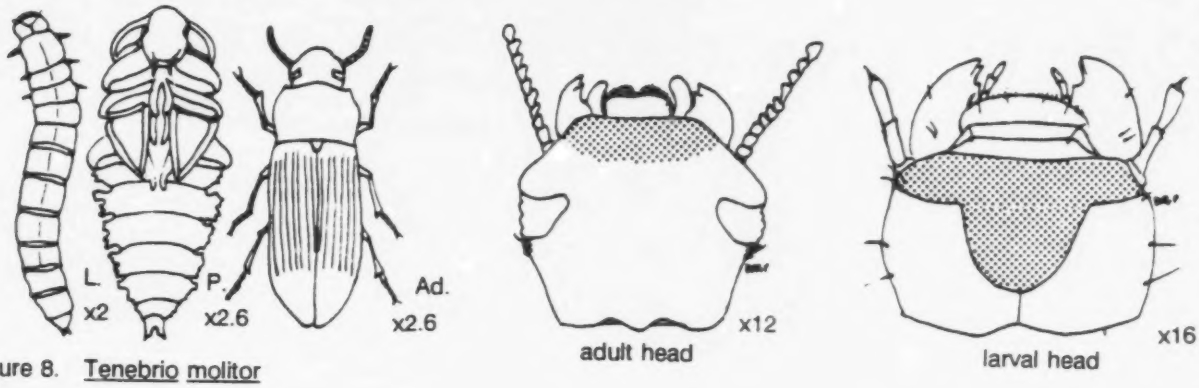


Figure 8. Tenebrio molitor

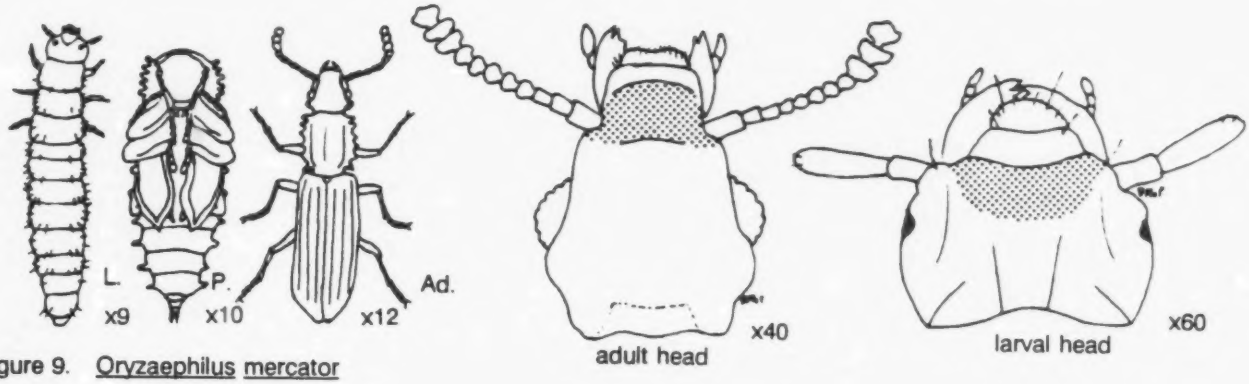


Figure 9. Oryzaephilus mercator

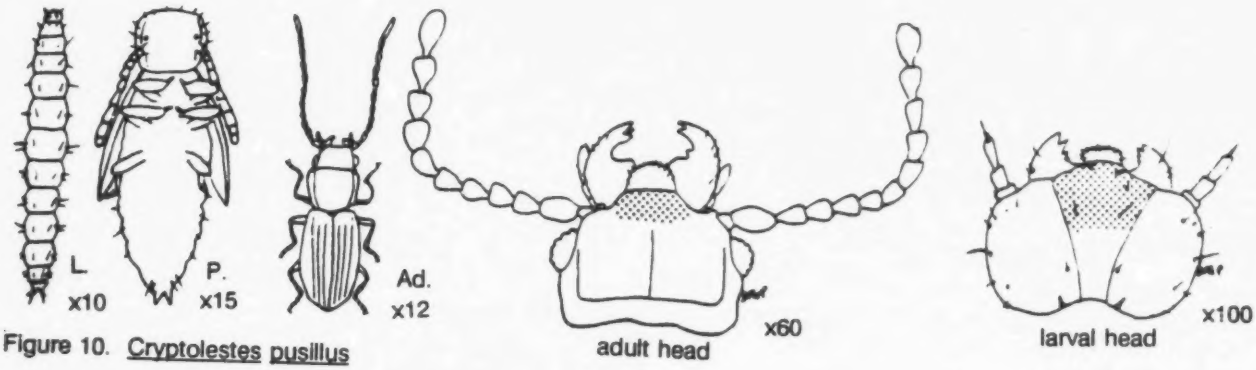


Figure 10. Cryptolestes pusillus

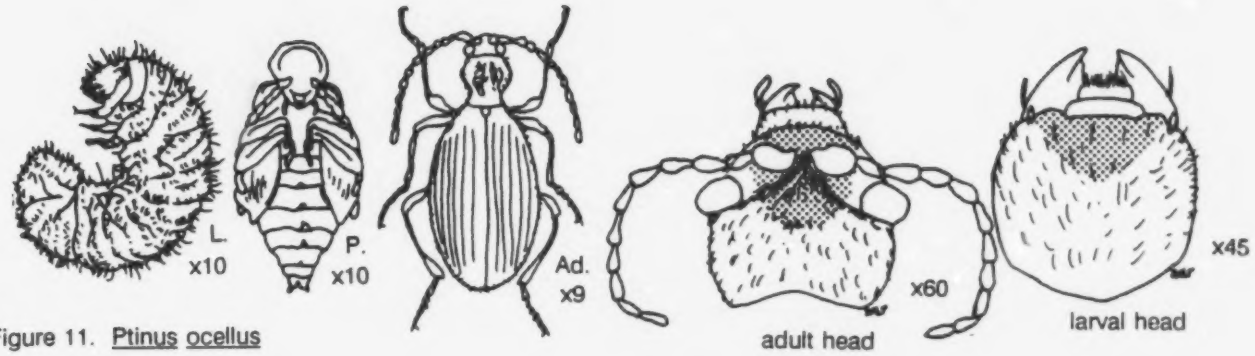


Figure 11. Ptinus ocellus

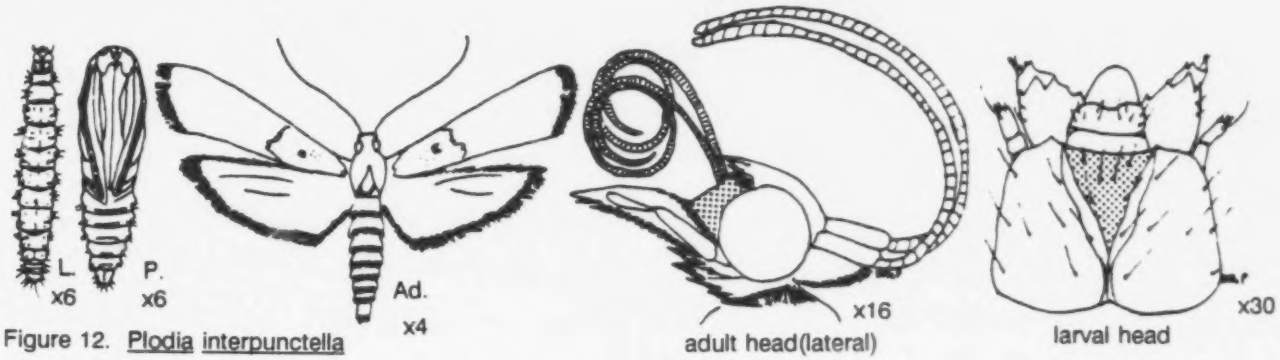


Figure 12. Plodia interpunctella

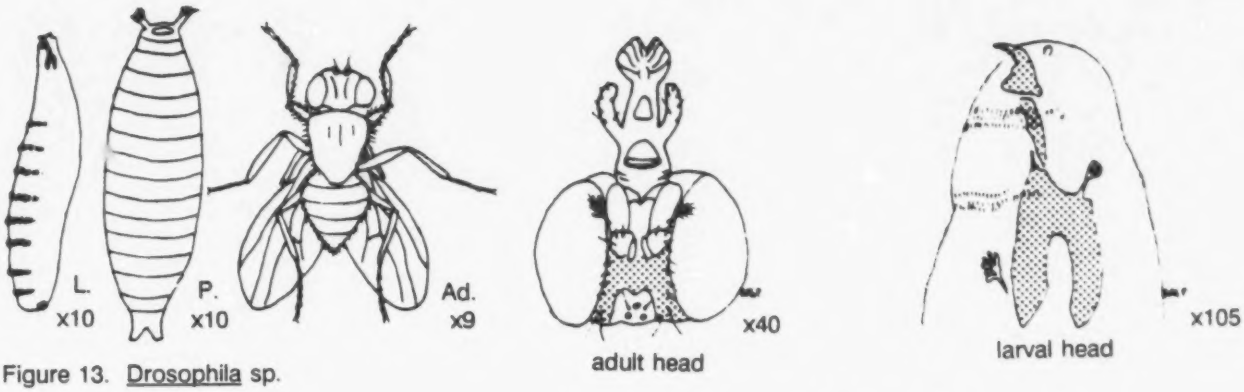


Figure 13. Drosophila sp.

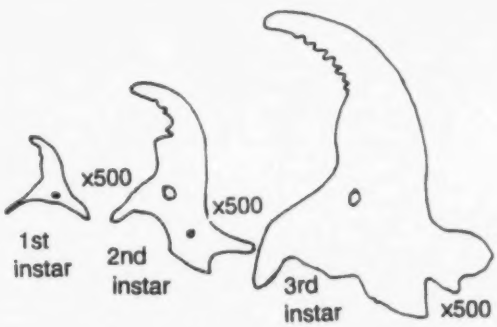


Figure 14. Drosophila anterior mouth hooks

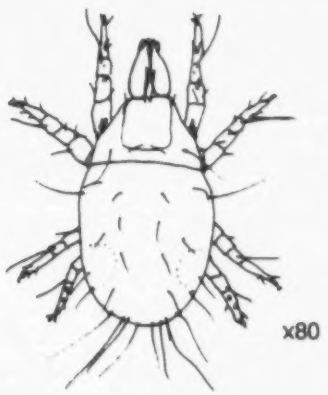


Figure 15. A mite, Aleuroglyphus ovatus

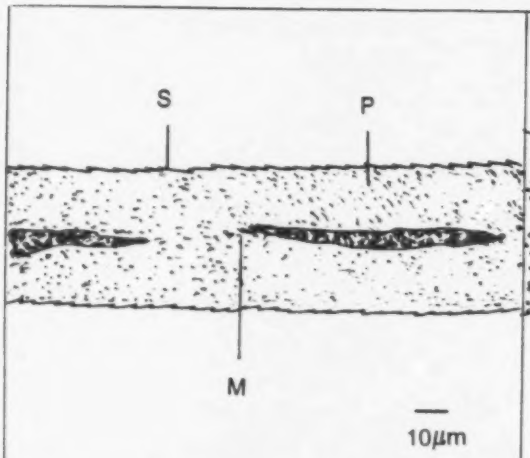


Figure 16. Human Hair

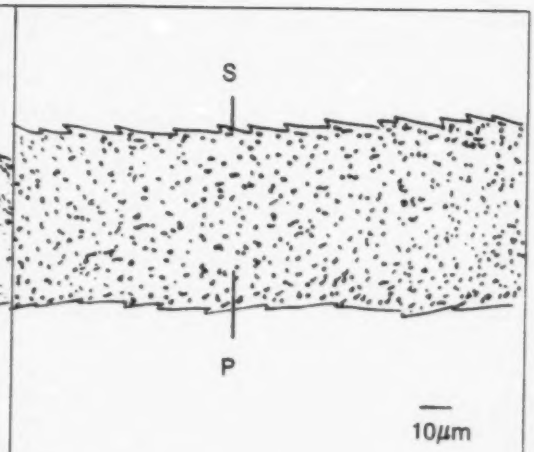


Figure 17. Sheep Hair

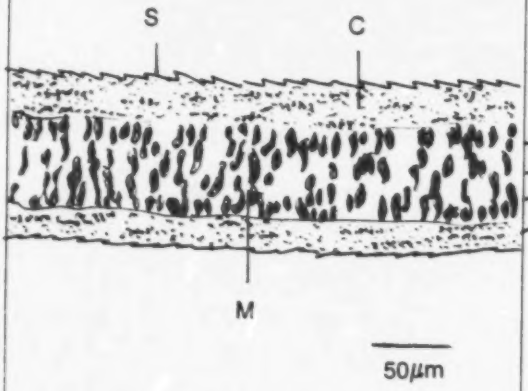


Figure 18. Goat Hair

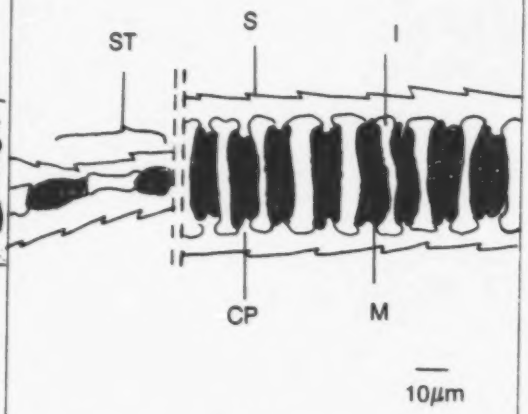


Figure 19. Mouse Fur Hair

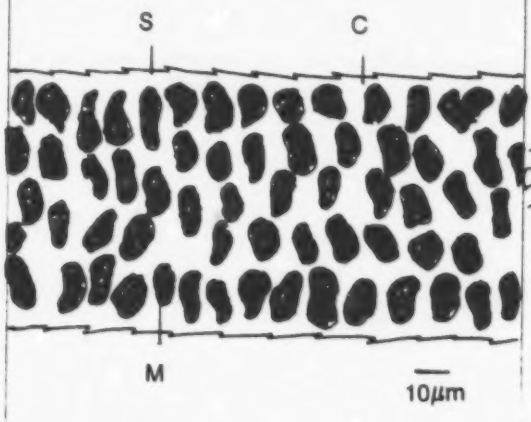


Figure 20. Mouse Guard Hair

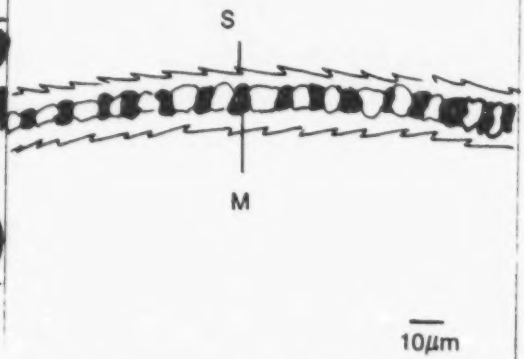


Figure 21. Rabbit Fur Hair

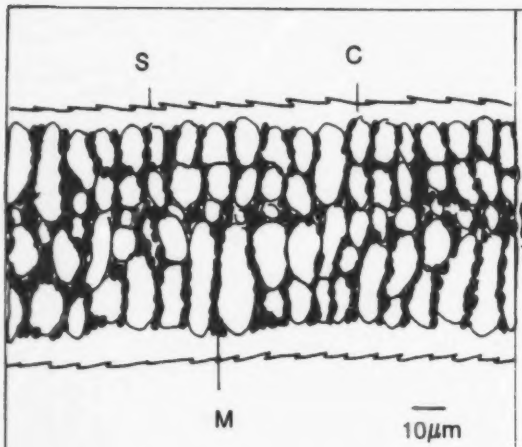


Figure 22. Rabbit Guard Hair

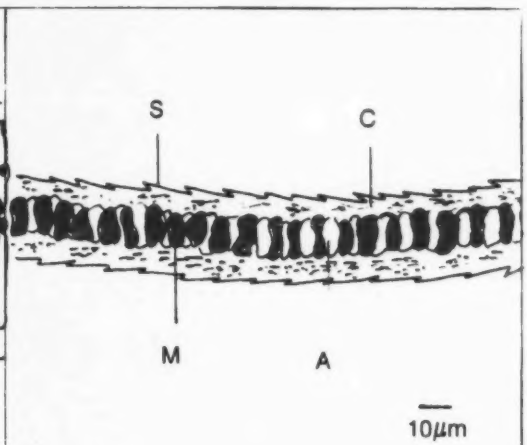


Figure 23. Squirrel Fur Hair

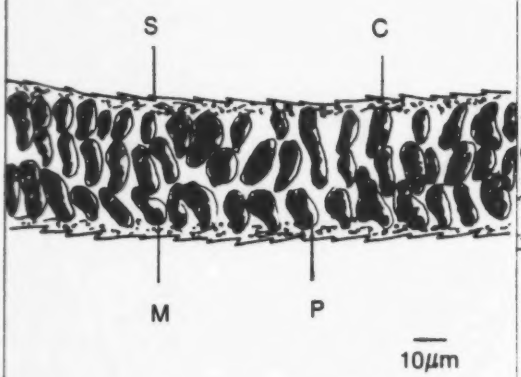


Figure 24. Squirrel Guard Hair

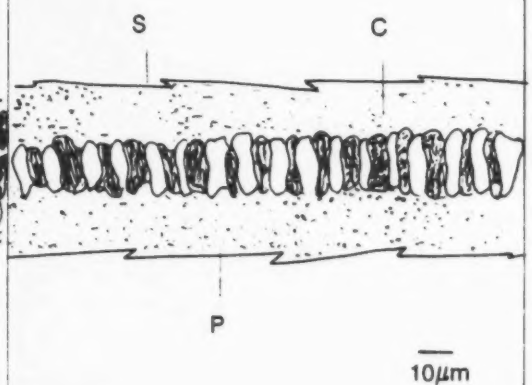


Figure 25. Dog Hair

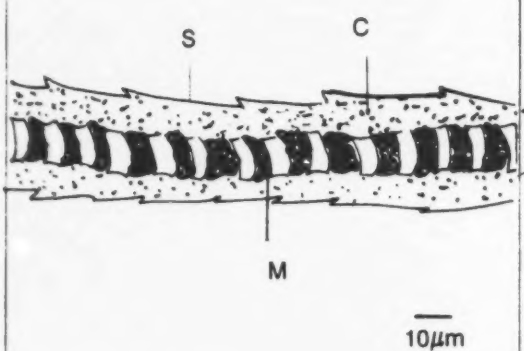


Figure 26. Cat Hair

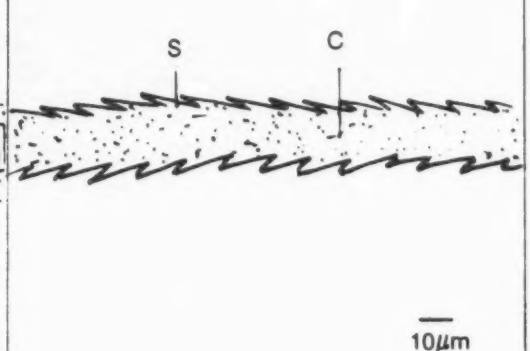


Figure 27. Bat Hair

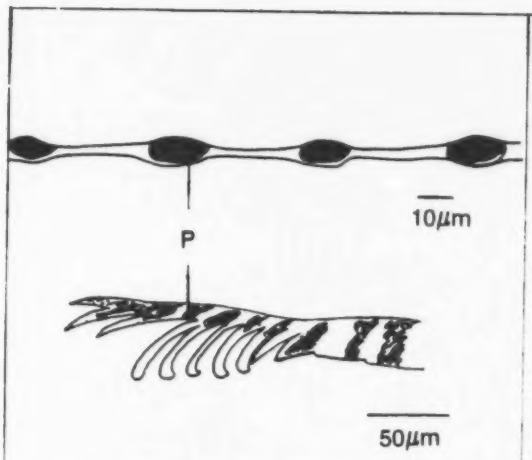


Figure 28. Feather Barbule

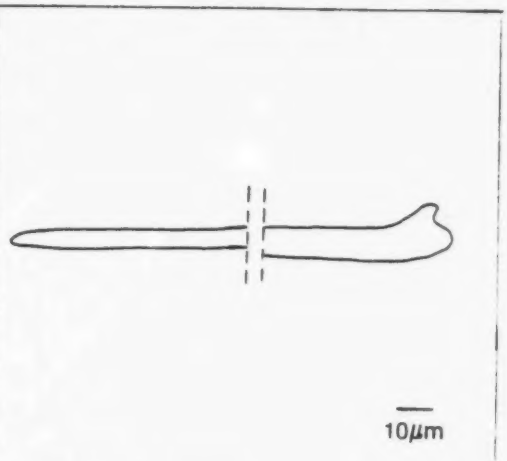


Figure 29. Wheat Hair

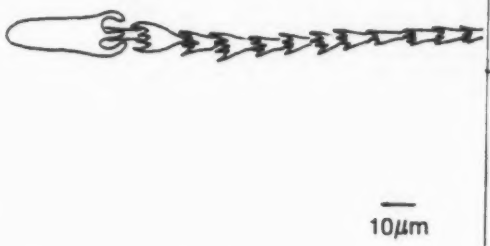


Figure 30. Dermestid (insect) seta

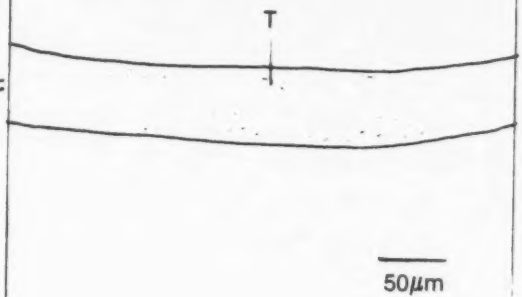


Figure 31. Nylon Fibre

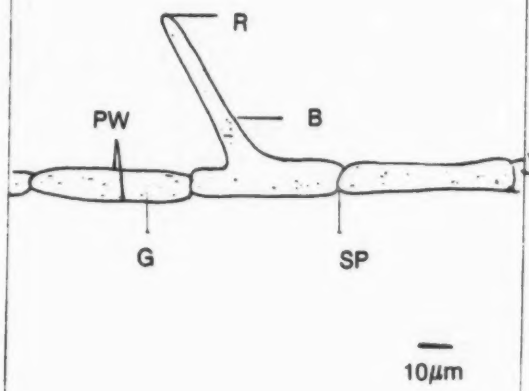


Figure 32. Mould Filaments

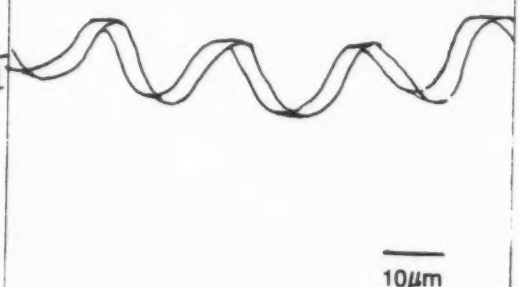


Figure 33. Fibrovascular Bundles

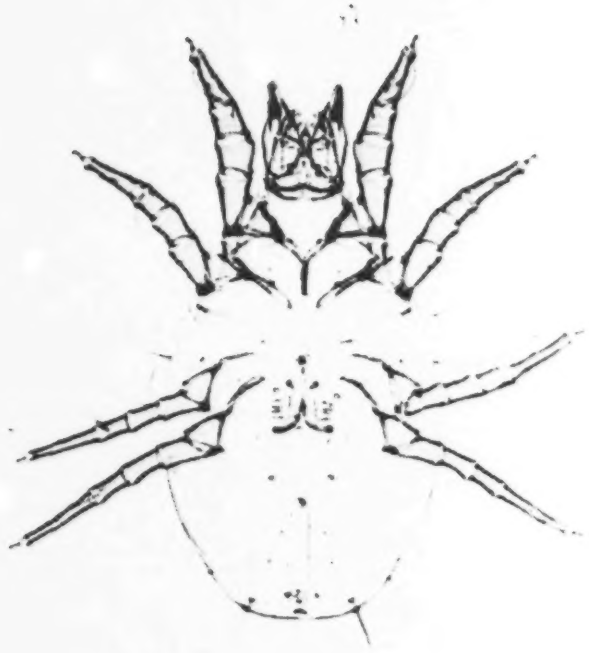
11. PLATES

Plate 1. Acarus siro female

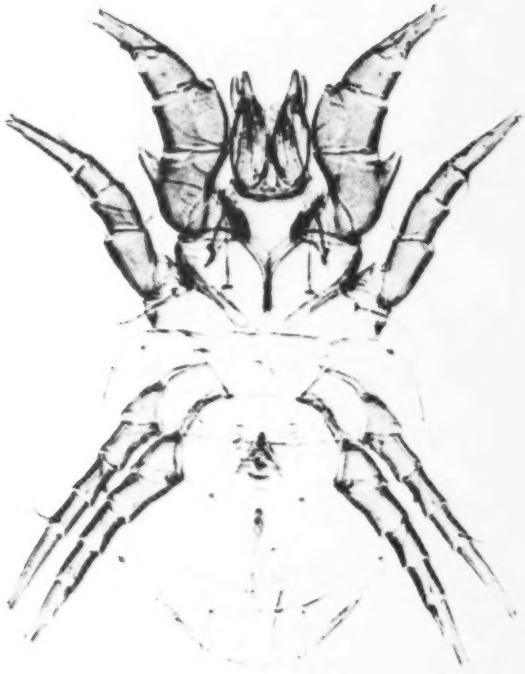
Plate 2. Acarus siro male

Plate 3. Mites(M) on Cheese

Plate 4. Mite Dust



1. 50μm



2. 50μm

3. 2cm

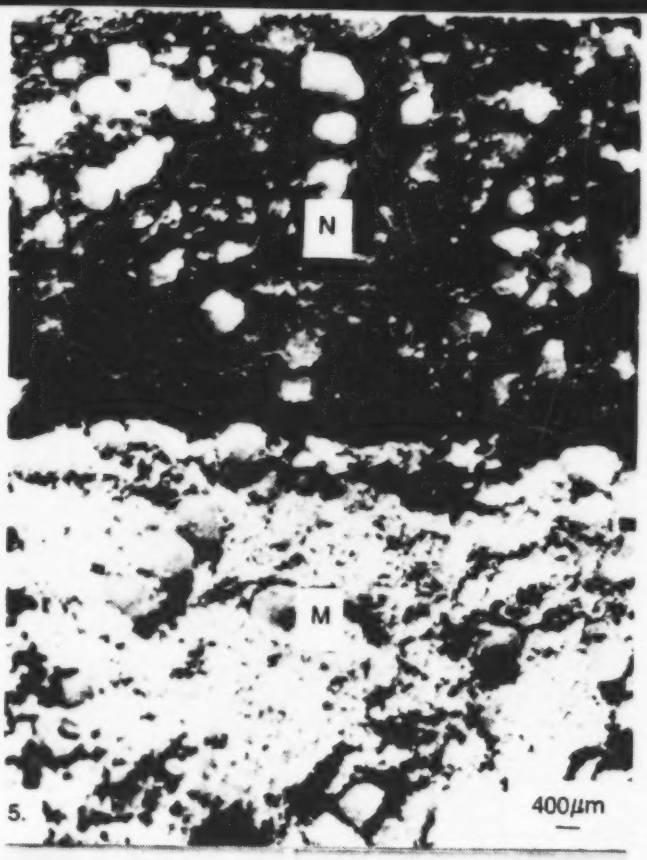
4. 200μm

Plate 5. Normal(N) and Mite-infested(M) Fig Paste

Plate 6. Empty Trap Flask

Plate 7. Full Trap Flask

Plate 8. Trapping Off



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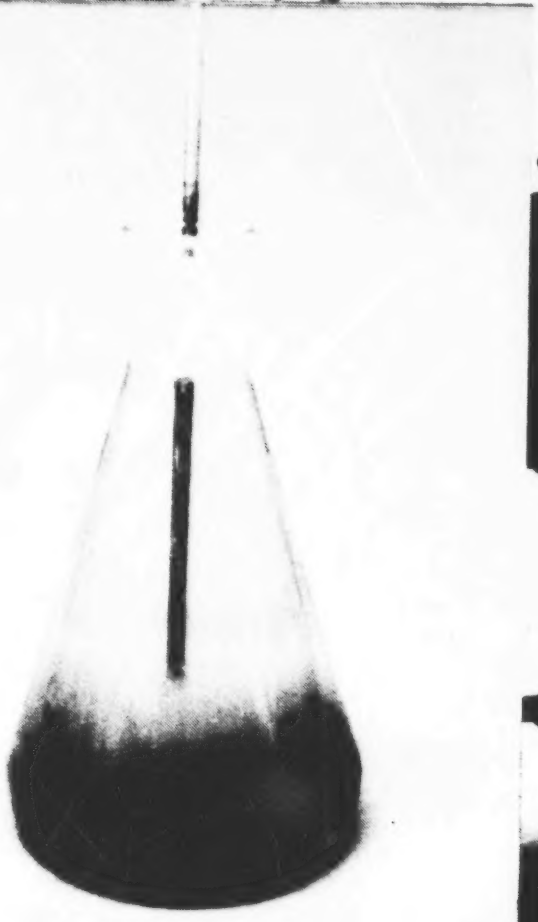
6.



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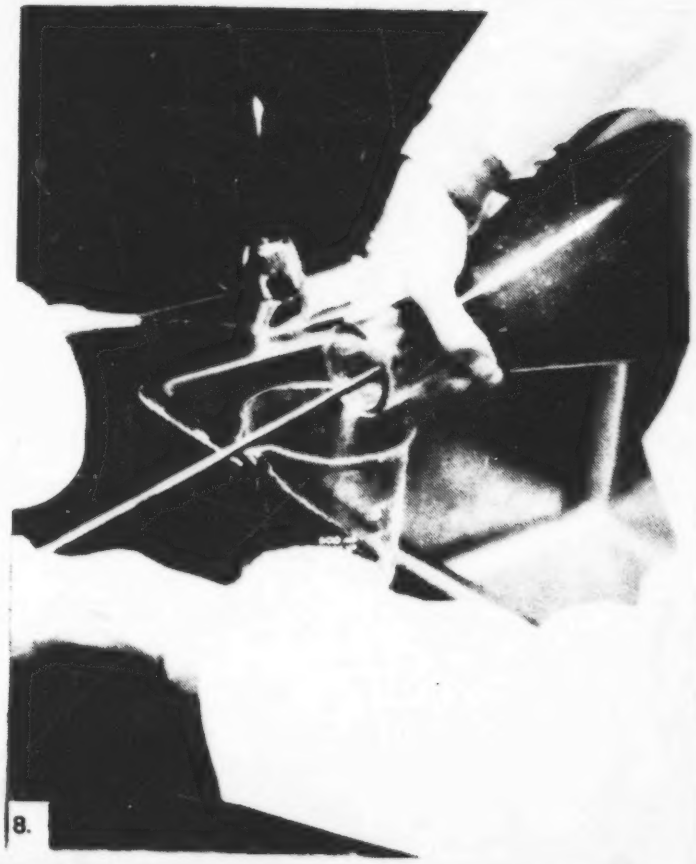
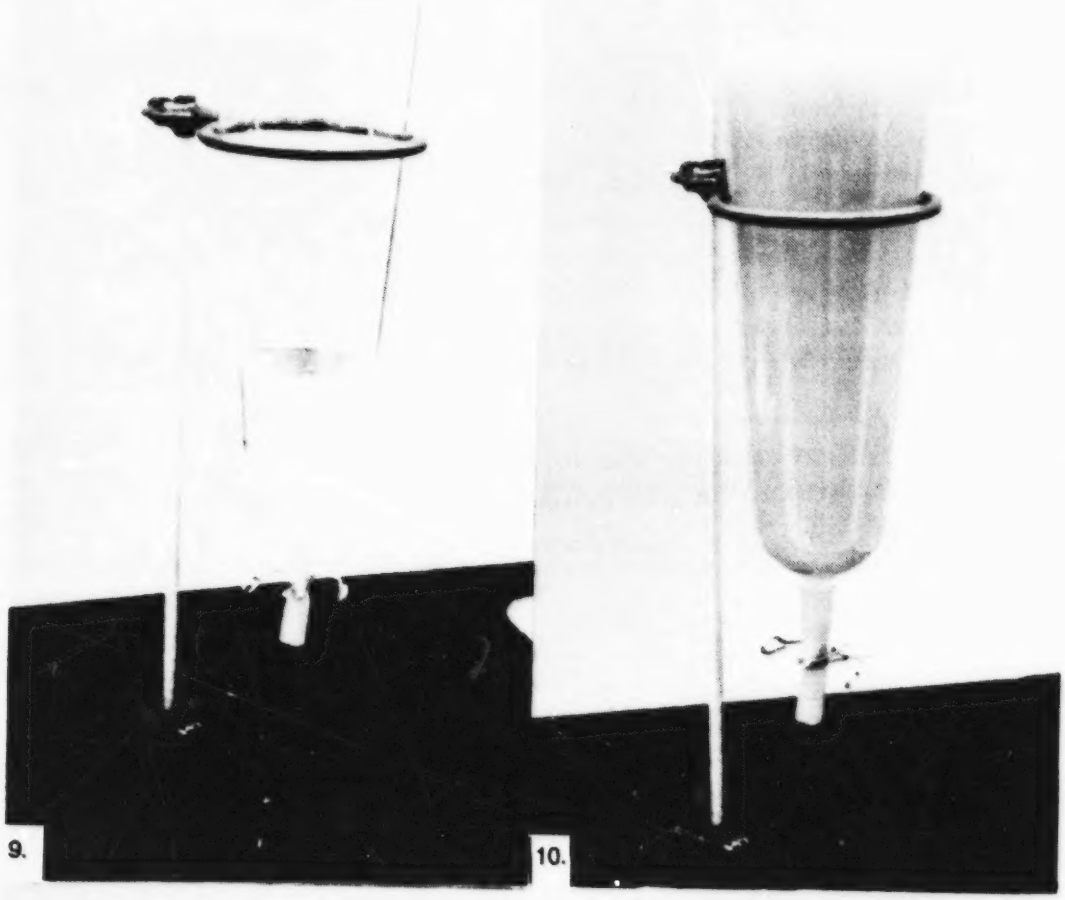


8.

Plate 9.	Empty Percolator
Plate 10.	Full Percolator
Plate 11.	Heavy Filth concealed in a Food Mixture
Plate 12.	Heavy Filth visible at the Bottom of a Beaker after Removal of Food Mixture



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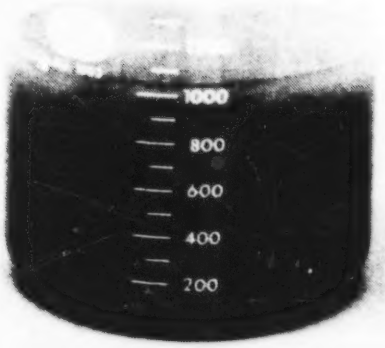
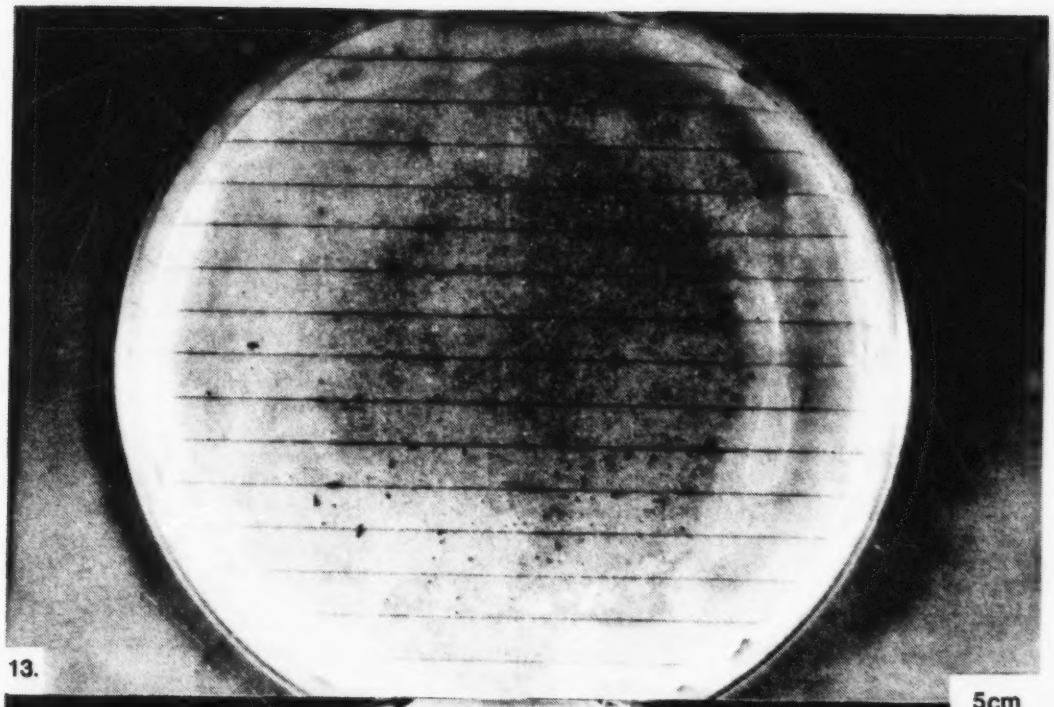


11.

12.

Plate 13. Light Filth Plate

Plate 14. Heavy Filth Plate



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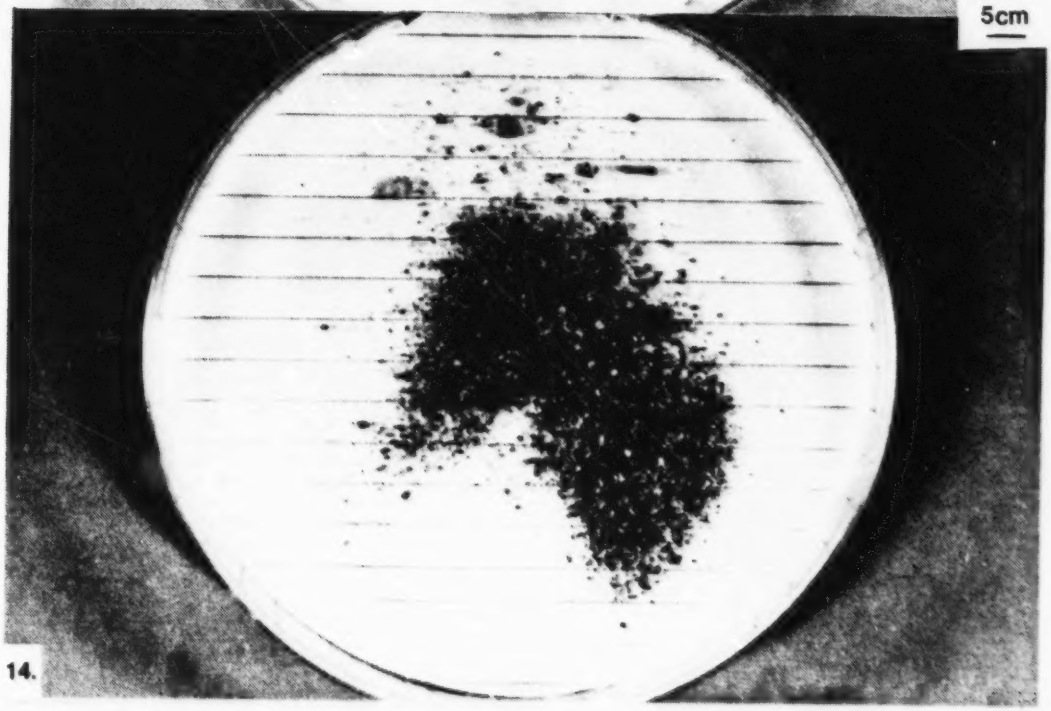


14.

5cm

Plate 15. Oryzaephilus mercator larva

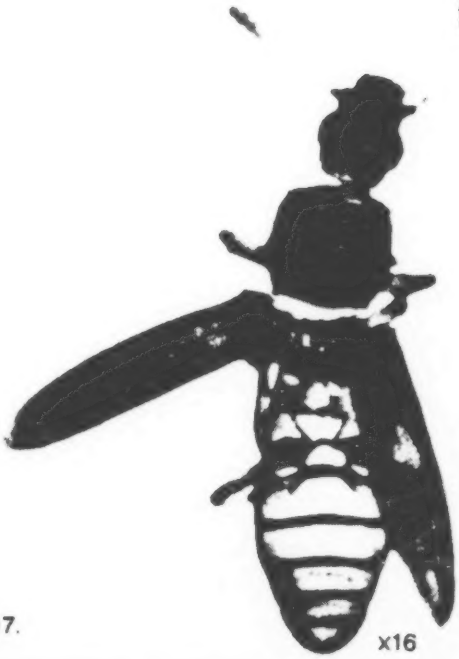
Plate 16. Oryzaephilus mercator pupa

Plate 17. Oryzaephilus mercator adult

Plate 18. Cryptolestes ferrugineus (adult male) Right and Left Mandibles

15. x26

16. x30



17. x16

18. 50µm